VOLUME 14 • NUMBER 3 • SEPTEMBER, 1941

Metals and Alloys

Published Monthly by Reinhold Publishing Corporation, East Stroudsburg, Pa., U.S.A. Ralph Reinhold, President and Treasurer; H. Barton Lowe, Vice President and Secretary; Philip H. Hubbard, Vice President; Francis M. Turner, Vice President. Executive and Editorial Offices, 330 West 42nd Street, New York. Price 25 cents a copy. Annual Subscription: U. S., Possessions and Canada, $2.00. All Other Countries, $3.00. (Remit by New York Draft.) Entered as second class matter June 12, 1934, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879.

Articles

Metallurgical Engineering Digest

Feature Section

After the Emergency

All of our readers will be interested and enlightened by the editorial on this subject.

Radiant Tube Furnace for Heat Treating

A type of heat-treating furnace, using radiant tubes in a new way, is described as applied to the heat treatment of aluminum alloy castings. Other data on the production of such castings are represented.

Modern Shell Forging

The various processes used in this country for making rifle-bored shells are reviewed by an authority in this field. Comprehensive information on this subject is eagerly sought.

Plastics and Metal Shortages

Mr. Chase discusses the extent to which plastics may ease shortages in certain metals—a subject of prime importance at this time. The article supplements one by the author in our April 1940 issue.

Our Steel Castings Output

The steel foundry industry of this country is an important one, but there is no organization which publishes data on the quantity of steel castings produced by the whole industry. This article attempts to supply this need for 1940.

Transformation Structures

Further data, supplementing discussions on this general subject previously published by METALS AND ALLOYS, are found in the last article. Certain 0.40 per cent carbon steels, plain and alloyed, are involved and the structures at different transformation temperatures are vividly presented in a series of photomicrographs.

Engineering Digests

Reinforced Cast Iron

Not that it always needs it, but cast iron for structural purposes can be materially strengthened by incorporating in it, during casting, mild-steel reinforcing bars, according to Russian experiments reported on p. 352.

Magnesium Production Methods

With new producers entering or rumored entering the magnesium metal field in this country, it is timely to have a brief outline, by Fox (p. 356), of the general methods for manufacturing this vital light metal.

Heat Treating Aircraft Gears

Aircraft gears are not exactly parts that the heat treater can toss into any old furnace while he spell-binds the plant stenographer elsewhere. Details of good practice for carburizing, hardening and tempering these "fussy" products are given by Buehler (p. 366).

Lead Welding

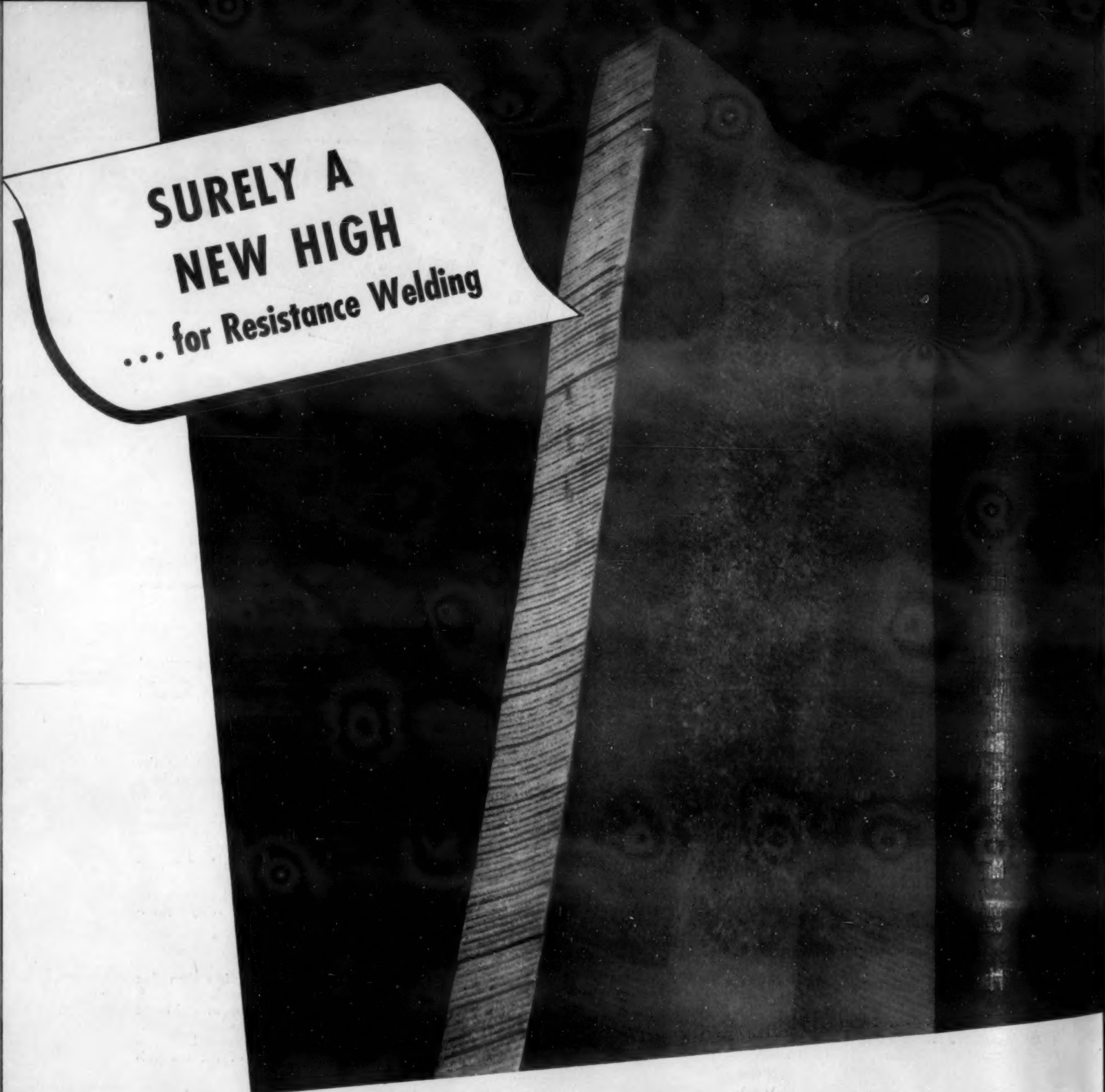
Pressure on the lead supply appears to be less than that on any other important commercial metal, with the result that it is being widely substituted for zinc, copper and other hard-to-get materials. This means the not-too-familiar technique of lead-welding will become more general. Eyles (p. 370) provides a practical description of the methods used.

Alloy Steel Castings

Of interest to American engineers will be Korschan's report (p. 372) of German juggling of alloy steel castings compositions to make manganese steels do for nickel-chromium, or even to use non-alloyed material where stress conditions permit.

Ride the White Elephant!

The government's silver-buying policy has left us with a backbreaking load of this metal, for much of which some industrial use must ultimately be found if the industry is to escape disaster. Recent research to find new uses (p. 378) has tended to feature substitutions of silver for such priority-controlled metals as tin, aluminum and nickel, and if successful may thus provide a partial answer to these 2 national problems—the silver hoard and the stategic-metal shortages.



187 *PIECES and Still Going Up---*

FOR those who have asked—"How many pieces of metal can I weld together at one time?"—here's *one* answer.

Pulsation welding, one of the many recent advancements made in resistance welding, enabled the temperature to be equalized across this entire assembly of 187 pieces, making a satisfactory weld.

This modern manufacturing method—resistance welding with electronic control and other modern equipment—is ideal for multiple assembly. It is adaptable to many types of such jobs and offers higher speeds and greater profits than ever before.

If you now use, or can use, resistance welding, you'll be assured of maximum production speed—which means profit, too—if you equip your welders with G-E electronic controls, contactors, circuit breakers, and cable. General Electric equipment is readily applied to existing installations or to new-machine installations. In *every* case, it will pay you to specify G-E equipment.

Full details from your G-E office, or write General Electric, Schenectady, New York.

GENERAL ELECTRIC

Editorial Expansion

To meet the increasing demands of stepped-up industrial activity and our own growing readership, METALS AND ALLOYS has made a long-needed addition to its editorial staff.

Henry R. Clauser, formerly in charge of the X-ray department at the Milton, Pa., plant of American Car & Foundry Co., has been appointed assistant editor of METALS AND ALLOYS. His responsibilities will include the editing of certain departments, the preparation of market information for manufacturers interested in our field, and general editorial work.

Mr. Clauser is a graduate of the University of Michigan, with a B.S. in Engineering, and brings to his new duties a broad, metallurgical engineering background combined with pronounced journalistic aptitude.—The Editors.

After the Emergency

It is obvious that the only way for a country to live in peace, amid the present generation of European and Asiatic madmen, is to be stronger than all of them put together and to be ready to use that strength. Strength is in raw materials even more than in finished munitions and men to use them.

This was recognized by the Service authorities long ago. The article "Strategic Raw Materials" by Major Roger Taylor, in our Vol. 1, No. 1 of July 1929 page 5, emphasized the necessity for stock-piles. The Army and Navy Planning Board consistently pled for stock-piles and were as consistently turned down by the politicians. The political cry was "Whom are we to prepare to fight?" Storage of essential materials was decried as giving the appearance of a war-like spirit. In the days of "mutual disarmament" where the United States scrapped ships and the others scrapped blueprints, such super-pacifist slogans prevented the fulfillment of the sane plans of the Army and Navy.

The Army and Navy held to their opinions and plans and lost no opportunity to present their case. They were backed by the opinions of civilian technicians on advisory committees, one of which, for example, advocated the establishment of a stock-pile of nickel, a precaution that was not seriously considered even by the Army and Navy in view of the supposed ready availability of all we could possibly use, but one that hindsight tells us should have been taken.

When the situation became so grave that distaste for stock-piles became not merely pacifist but traitorous, there was too little time left for the collection of adequate stock-piles, in view of the shipping situation, so that we do not yet have a truly adequate stock-pile of any of the strategic, critical, or scarce materials and have to figure on utilization of low grade domestic ores where we have them, or of substitutes for the metals that do not occur in the United States.

When the emergency is over, our first duty should be to build up those stock-piles, and to build them from foreign materials for which we can trade manufactured products. foodstuffs, etc. whose production will give employment in the after-emergency depression.

Even though the utilization of low-grade manganese ores, low-grade bauxite, alunite, etc. has progressed so as to be technically feasible, those sources should then no longer be drawn upon, but be left in the ground as further stock-piles, with only enough operation of mines and concentration plants to keep them in running shape and keep their technology developing.

Political pressure will be exerted by owners of low-grade deposits to keep up large scale operations. The "producers" of low-grade manganese ores have been especially vociferous in their requests for use of their ores in spite of their uneconomic position.

It is far better, between emergencies, to keep the raw materials in storage as stock-piles of high-grade foreign ores, and in the ground as low-grade domestic ores than to fabricate them into finished planes, munitions, etc., for when the next emergency comes, those products, made earlier, will have become obsolete. If we want to be ready for a 1955 emergency, stock-piles and unused ores in the ground will enable us to produce 1955 models of the weapons of war.

The legislation that provides for a modest stock-pile of tin, not yet wholly accumulated, further provides that the stock will be held for something like five years, after which it could be sold to civilian

(Continued on page 324)

Radiant Tube Furnace for Heat Treating Aluminum Alloys

by EDWARD A. SCHMELLER

Chief Metallurgist,
National Bronze and Aluminum
Foundry Co., Cleveland

There are several types of furnaces in which aluminum alloy castings can be heat treated—fuel fired, direct or indirect; electric; salt bath; and so on. The selection of one of these is affected by local conditions, types of castings that must be heat treated, and cost.

Two main reasons influenced the selection by the National Bronze and Aluminum Foundry Co. of a radiant tube type for certain of its products—cost of operation and necessity of heat treating certain castings not directly heated by the products of combustion.

This article describes the new type of radiant tube furnaces recently installed, as well as the heat treatment applied.—The Editors.

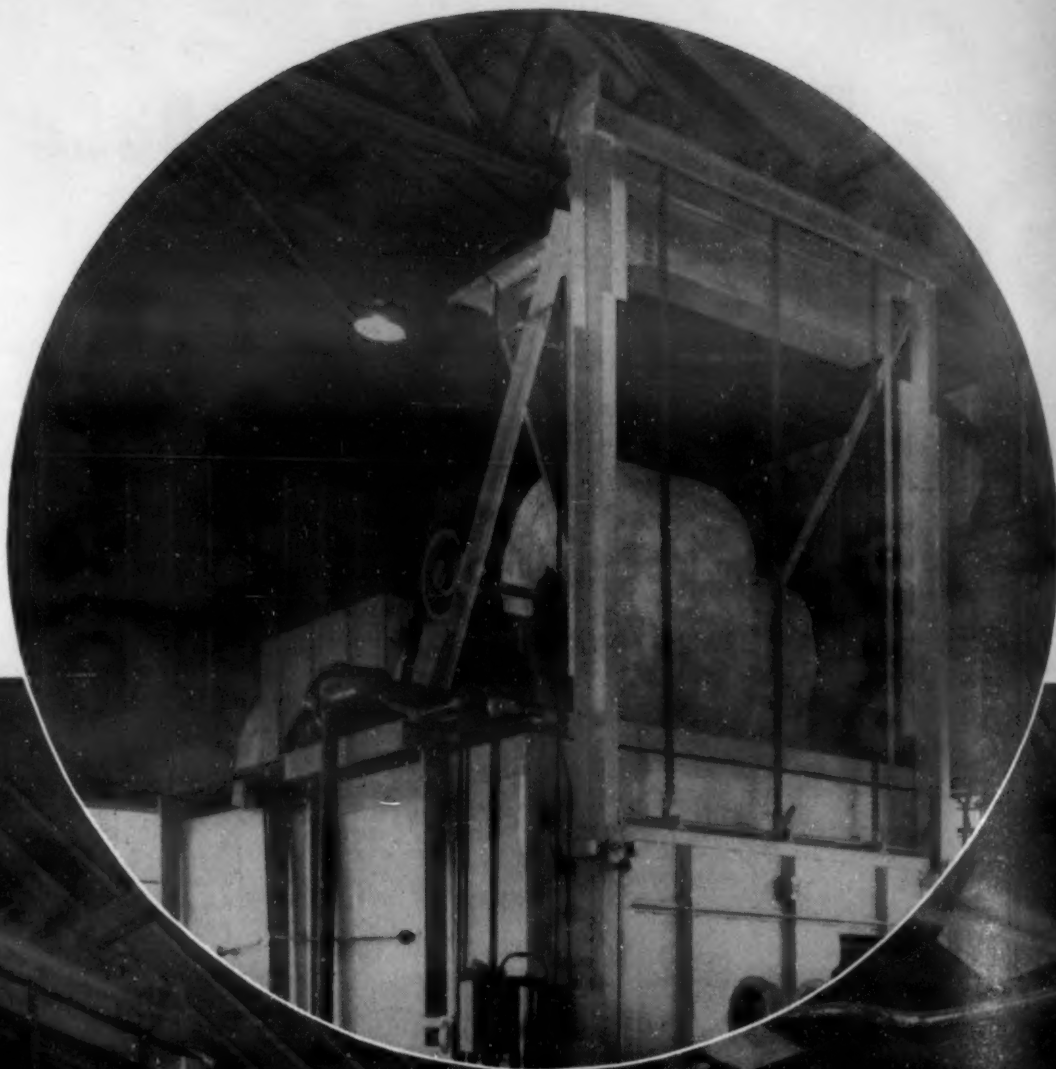
In the American Defense Program, aluminum alloy castings are one of the many metal or alloy products which are used on a large scale. In this War of Metals, they are essential in many types of fighting equipment—airplanes, tanks, trucks, and so on. The demand for them is enormous.

One of the American plants which is meeting part of this demand is the National Bronze and Aluminum Foundry Co., Cleveland. This large foundry is producing, among other products, castings which are used for differential housings for army tanks, aircraft engine parts, airplane wheels, airplane parts, bomber nosings, aircraft castings and Diesel engine parts and many others, mostly for airplane manufacturers.

As in the case of steel castings, heat treatment of many of these materials is necessary to bring out their best properties. The Cleveland company has recently installed some heat-treating furnaces for treating these aluminum alloy castings. The furnaces, particularly the radiant tube units, present some interesting features. There are two radiant tube gas furnaces, one direct gas-fired furnace, all built and installed by the Despatch Oven Co., Minneapolis, Minn., and one rotary, direct-fired unit.

Aluminum Alloys Heat Treated

There are four principal types of aluminum alloys which are being incorporated in the castings which this company is producing, designated as Alcoa Nos. 355, 356, 195 and 142. Their composition, as given in the Table, are those used by the company. Other compositions are also used. The castings are all made in sand or permanent molds from metal melted in reverberatory gas furnaces, or pit-type crucible furnaces.



View of the radiant tube heat-treating furnace, ready for charging. The radiant tube furnace with the door closed, showing the tube heater on the roof with the fan back of it. The racks loaded with castings are ready for heat treating.

Two small reverboratory type melting and holding furnaces with a capacity of approximately 6,000 lbs. each. There are two other larger furnaces of this type for melting alloys which have a capacity of 55,000 lbs. each.

After the usual operations of cleaning, chipping, etc., they are ready for heat treatment.

For heat-treating certain types and compositions of castings, a radiant tube type of system is employed. It was decided upon because no products of combustion must come in contact with the certain parts being heat treated. On certain aluminum alloys, products of combustion are not detrimental but on others they are very undesirable. For this reason, the Despatch furnaces, installed in this plant, are equipped with either radiant tube heaters or with direct gas-fired heaters depending upon the materials placed in the furnace.

The Radiant Tube Furnace

The special radiant tube furnaces here employed are so constructed that they may be quickly installed in special panel sections. Complete erection, ready for maximum production, requires only 8 days. Because of this special panel construction, a furnace can be easily moved or enlarged, if desired.

The dimensions of the furnace are as follows: Inside, 7 ft. wide, 8 ft. high and 15 ft. long; overall, 10 ft. wide, 9 ft. high and 16 ft. long. This does not include the heater or radiant tube equipment which is located on top of the unit. About 5,000 to 10,000 lbs. of aluminum alloy castings are placed on the special car, as shown by an illustration, which can be moved in and out of the furnace.

These Despatch furnaces are said to be an entirely new type as to body construction. They do not have the customary refractory or insulating brick construction since specially designed panels are used. The panel of the interior wall of the furnace is 18 and 8 stainless steel with the exterior panel of heavy 16 gage steel. The space between these is 8-in. of insulation so as to keep heat losses at a minimum. These panels are heavily reinforced, vertically and horizontally.

Attention is called to the fact that, since these panels are fabricated at the factory, the furnaces are easily constructed, expanded or moved; and also that the radiant tubes are externally located. It is pointed out that by having the heater thus externally located, all radiant heat is completely eliminated from the interior of the furnace—considered essential and desirable for furnace operating temperatures up to 1,000 deg. F.

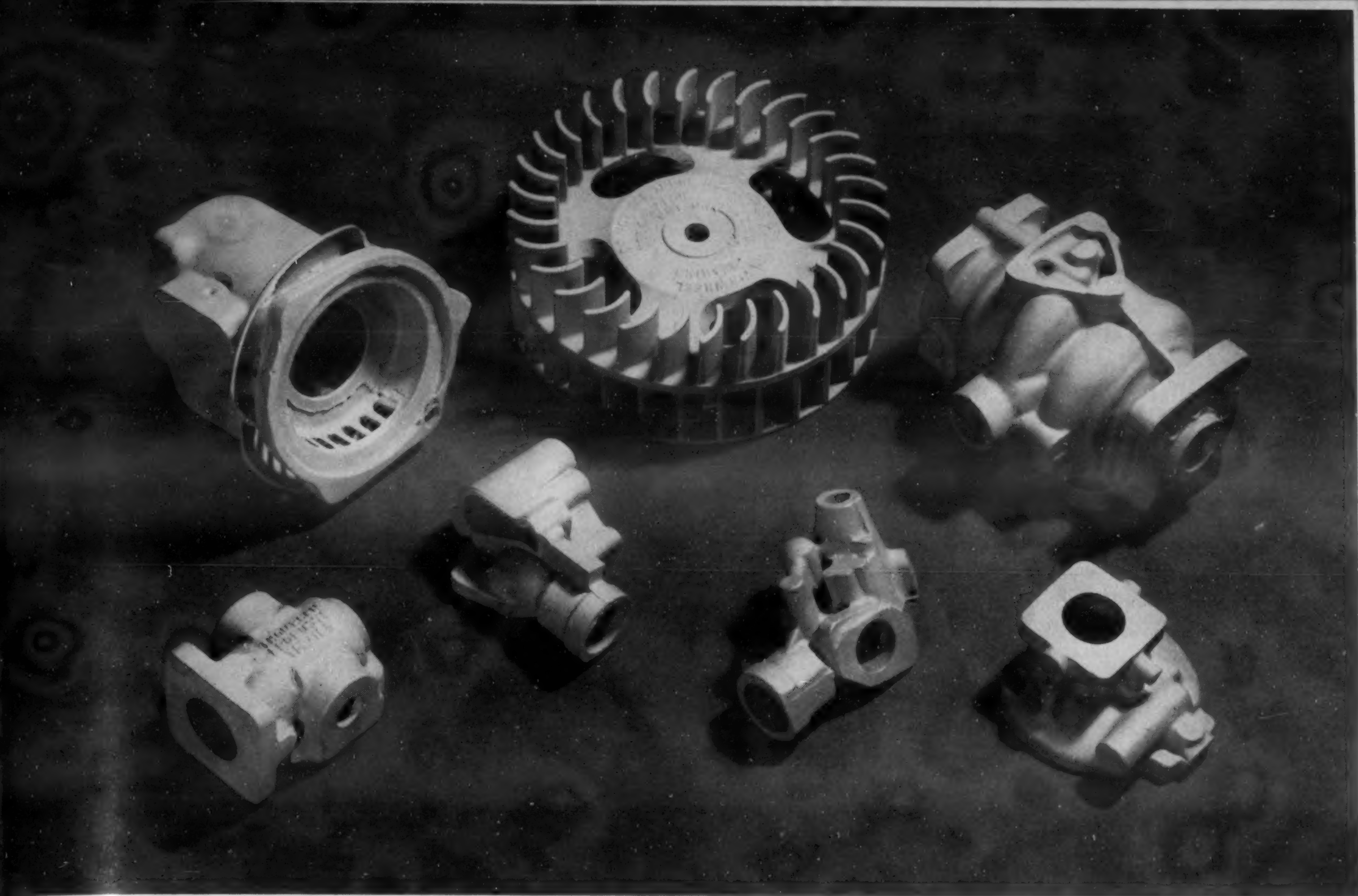
Heating by Convection

The entire furnace is heated by convection and there is, on top of the furnace and near the heating unit, a very large, high pressure alloy steel fan that delivers air in the work chamber of the furnace at a velocity approaching 60 to 70 miles per hr. Thus, it is claimed, the heat transfer is very rapid and the entire interior uniformly heated.

The heated air is distributed into the furnace through a specially arranged heat distributing duct system, placed along the side walls and in the bottom of the furnace. The ducts are each provided with

Five pot melting furnaces each with a capacity of 550 lbs.

An aluminum alloy Diesel engine crankcase for the American Locomotive Co. It weighs 3,500 lbs. and is claimed to be one of the largest aluminum castings ever produced.



A group of miscellaneous small castings of aluminum alloys, also produced by this company.

ports and adjustable slide dampers for each port. There are recirculation ducts in the top of the furnace, similarly arranged. All ducts are made of 18 and 8 stainless steel. The interior uniformity of temperature is said to be within 5 deg. F., plus or minus—decidedly important in the successful heat treatment of aluminum alloy castings.

The operating costs are claimed to be low because of the use of this indirect gas heating system. According to the Despatch company, recent tests have shown that the maximum gas consumption was 27 cu. ft. of 1100 B.t.u. gas per min.

The maximum temperature obtainable in the radiant tube furnaces at the National Bronze Company's plant is 1,000 deg. F. However, the builders say that these units can be arranged for higher internal temperatures—say up to approximately 1250 deg. F. —if necessary. It is expected that ultimately higher temperatures will be obtained.

The tubes of the radiant heating unit are made of a special high chromium, high nickel steel alloy, capable of giving long continuous service at temperatures up around 1800 deg. F. Actually, says the Despatch company, measurement of the temperatures of the tubes indicates that these never exceed 1400 to 1500 deg. F. so that their life should be almost indefinite. The actual composition of the tubes cannot be revealed.

Loading the Castings

In loading these radiant tubes furnaces, special frames with adjustable contact points to create proper tension and supports are provided to prevent the overhanging parts of the castings from warping or sagging out of shape—due to the reduction in hardness and yield strength of the alloys at the temperatures at which they are heat treated. When large quantities of small castings, as sometimes happens, are to be treated, it is not possible to pile these over two or three high depending on their size and weight. The shape of certain castings could thus be disturbed while at the heat-treating temperature.

After the castings have been subjected to the proper temperature, the door of the furnace is opened and the electrically operated car, holding the special frames and the castings, is moved out and the castings quenched. Thus the loading and unloading is facilitated. It has been found that heavy racks divided into sections, worked out to better advantage from the quenching standpoint for the conditions involved at this Cleveland foundry than any other type of loading equipment. One of the illustrations shows this car and its loading equipment. Castings weighing from 1 oz. to 3,700 lbs. are thus loaded and heat treated. In these furnaces about 16,000 lbs. of bulky castings can be heat treated and up to 38,000 lbs. of others per 24 hrs.

The Heat-Treating Cycles

The radiant tube heat-treating furnace can be used for either solution heat treatment (heating and quenching) or for normalizing and precipitation (aging) treatments. Castings which require the solution treatment are heated for periods up to 18 hrs. and at temperatures up to 1000 deg. F., the time and temperature depending on the particular alloy. They are then removed, special racks and all, and quenched in boiling water. For the normalizing or precipitation treatments, somewhat lower temperatures in the range 200 to 600 deg. F. are used in heating with times up to 20 hrs. depending on the alloy and properties desired.

As indicated in the early paragraphs of this article, there is a new direct gas-fired furnace installed recently by the Despatch Oven Co. This furnace is used for heat treating special classes of castings. Either the heating and quenching or the normalizing or aging treatments can be and are being used.

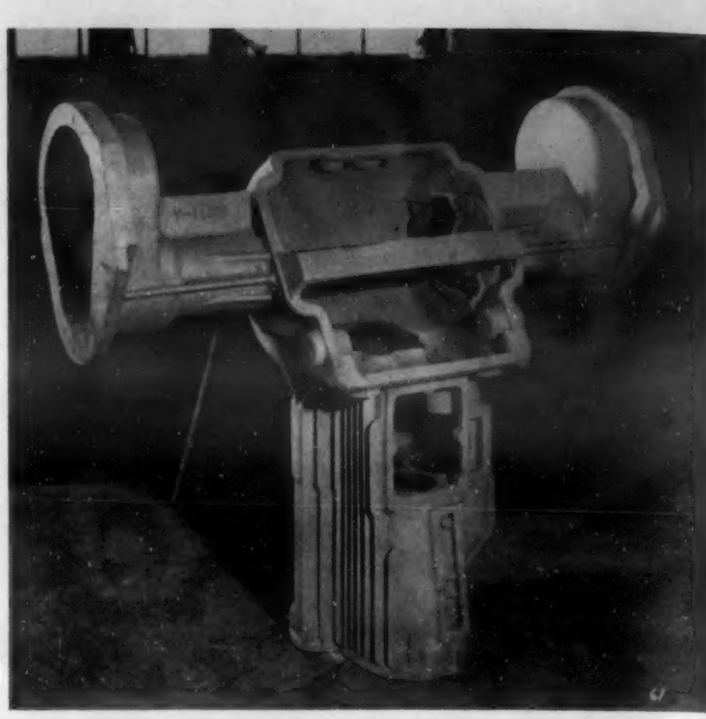
The rotary furnace, also previously mentioned as part of the company's heat treating facilities, is used only for normalizing.

It is understood that this is the first instance of the application of a radiant tube furnace, with the heating unit externally situated to the heat treatment of aluminum alloy castings.

Table of Composition of the Aluminum Alloys Heat Treated in the Radiant Tube and other Furnaces

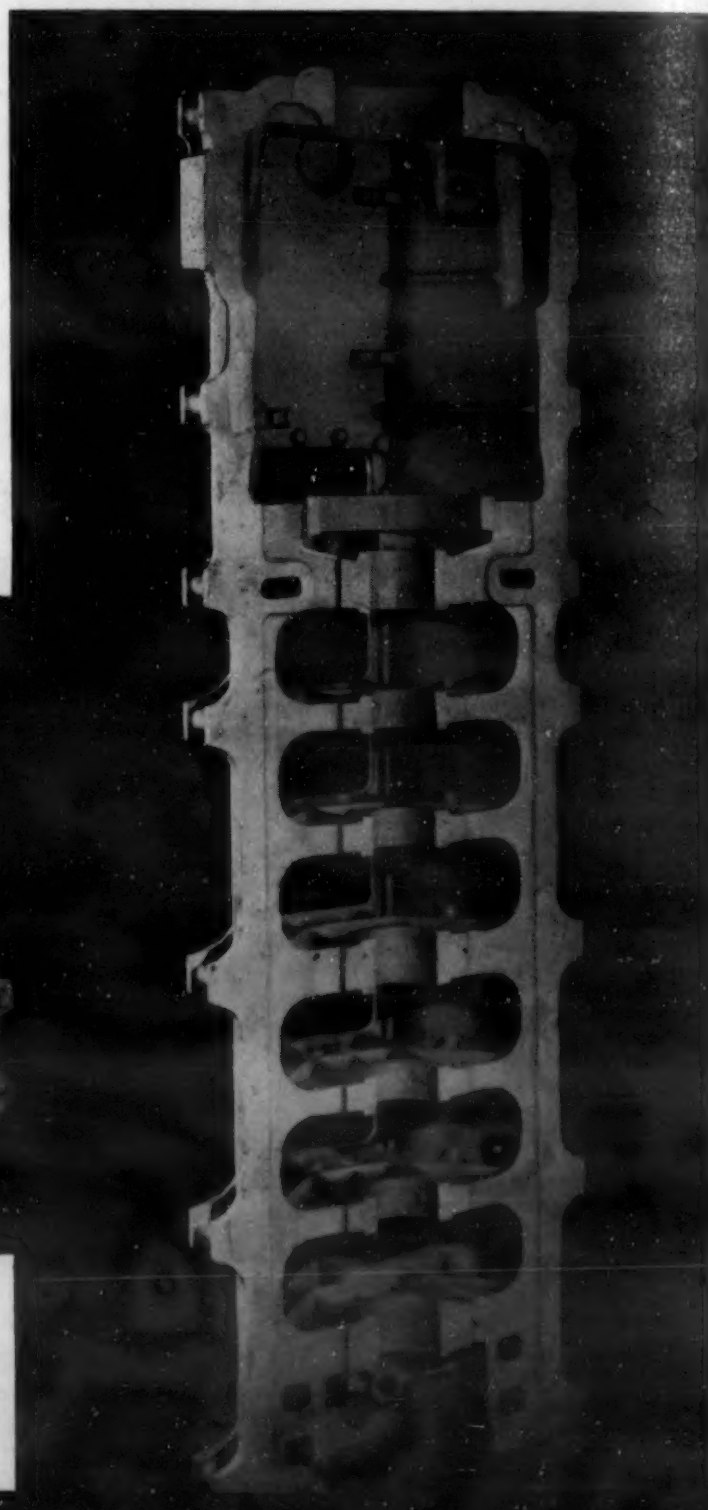
	335	356	195	142
Copper	1 to 1.50	0.20	4.0 to 5.0	3.5 to 4.5
Iron	0.50	0.50	1.00	0.80
Magnesium	0.40 to 0.60	0.20 to 0.40	0.03	1.2 to 1.8
Manganese	0.05	0.03	0.03	0.01
Nickel	0.03	...	...	1.7 to 2.3
Silicon	4.5 to 5.5	6.5 to 7.5	1.20	0.05
Zinc	0.03*	0.03*	0.03*	0.03*
Titanium	0.20	0.20	0.20	0.20
Aluminum	Balance	Balance	Balance	Balance

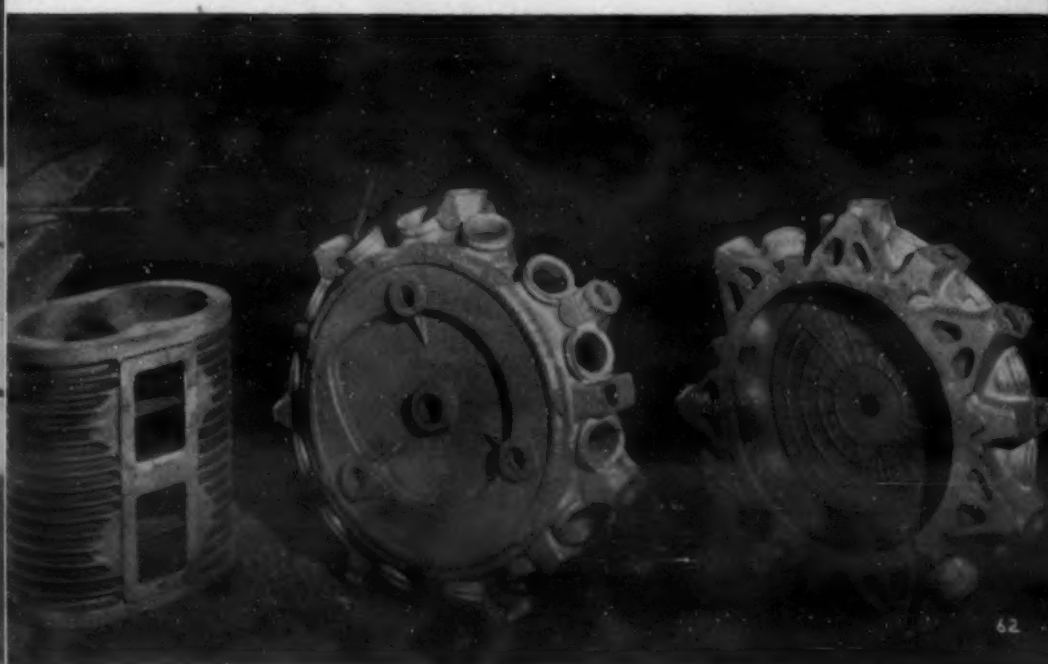
* Minimum.



An aluminum alloy differential housing for Army tanks.

A Sterling engine crankcase for Navy ships, made of aluminum alloys.





The two castings at the right are front and back views of Wright aircraft engines. At the left is a supercharger housing for the McCulloch Engineering Co. All are aluminum alloy castings.

by F. G. SCHRANZ

General Manager, Baldwin Southwark Div.,
The Baldwin Locomotive Works, Philadelphia

The familiar "plowshares into swords" idea is applied no more universally than in the many plants normally forging and forming peacetime products. As the author points out, practically all must convert their press equipment to the forging of shell bodies in times like these. Comprehensive information on equipment and methods employed for forging steel shells is, therefore, of very broad interest.

This article reviews the various processes employed in this country for making rifle-bored shells, and is of value not only for its detail but for the impartial, objective viewpoint adopted by the author.—The Editors.

Modern Shell Forging Methods

THE forging of steel shell bodies during wartime is of interest to almost any manufacturing company that has been forming, flanging or forging steel products during peacetime. Our own and friendly governments rely on such companies in periods of war or national preparedness to produce millions of shell forgings of all sizes ranging from forgings of 1½ in. diam., weighing 2½ lbs., to those of 16 in. diam., weighing over 2,000 lbs. It has been stated that in this war, during an airplane attack, more than 600,000 anti-aircraft shells have been fired by one European nation in a single day.

Billets

The shell forging has its start in the rolling mill where steel bars in round or square shapes of required section and length are rolled from blooms or ingots. Each heat from which an ingot is cast is numbered; this heat number is recorded as to its chemical and physical properties and the heat number is stamped on all steel bars from which the billets for shell forgings are cut. This heat number is identified on each shell forging made from any specific heat.

After each rolled bar has been inspected at the steel rolling mill the shipment of bars goes forward to the shell manufacturer. There, the bars are stored according to the heat numbers.

Nicking and Breaking

The first operation on these bars is cutting them to the length necessary for the required size of shell forging. Various methods of cutting these steel bars into individual billets are employed.

During the last war mostly round rolled billets were used, which were cut from round bars on multiple-head cutting-off machines or saws. The most desirable method now is nicking and breaking of square bars.

Nicking can be done under a hammer, mechanical press or hydraulic press, where the steel bar is nicked by "V" shaped nicking tools on opposite sides of the bar. This method is most applicable to square bars. Another method is the cutting of billets by means of power hack-saws or circular saws.

Particularly on square billets, gas cutting is frequently used either for cutting each individual billet to length or gas-cutting a double length billet which, at the same time, is gas-nicked in the middle only on one side of the billet or on both sides, depending on the size of billet and the method of breaking. Some shell forgers gas-nick a full length bar on opposite sides to individual billet length.

Nicked billets are then broken under mechanical or hydraulic presses. It is desirable to have at least one broken surface on each billet to permit inspection of the fracture for seams or defects which may occur in the rolling operation of such steel bars. When gas-nicking, it has been found that a more uniform or square breaking surface is obtained by chilling the hot-gas-nicked cut with a cold stream of water. The broken surface of the billet, after being heated for the piercing operation should, when placed in the piercing pot, face the piercing punch, thus allowing clean metal to be displaced on the inside cavity

of the shell. If the gas-cut surface is exposed, slag from the gas-cut surfaces may cause imperfect cavities.

Finished Cavities

During the last war, all shell forgings were machined on the inside cavity, but the specifications now call for finished forged cavities, *i.e.,* no machining operations in the cavities of the shell are required.

This necessitates perfect forging conditions as to clean metal and concentricity of forgings. Such requirements can be met only by clean metal on the surface of the billet and, in particular, where the piercing punch enters the billet. This surface must be carefully descaled after the billet leaves the furnace, and the piercing punch surface and punch nose must be in good condition at all times. Scored piercing punches will produce scored cavities, and can also cause eccentric forgings, as the scored side of a piercing punch offers much resistance to friction when entering the hot billet, thus forcing the piercing punch to one side. Such eccentric shells caused by defective piercing conditions can never be rectified in the drawing operation.

A sufficient supply of piercing punches, piercing pots, ejector pins with base dies, drawing mandrels and drawing rings should be on hand at all times. When such tool parts become slightly worn, they should be replaced promptly. Slight tool wear of this type can be readily redressed. It is better to stop the operation of the forging presses for a few minutes to change mandrels and rings than to produce forgings at the rate of 2 to 5 per min. which, later on, will have to be rejected due to scoring of the cavity or outside surface, or to exceeding the limit gauge as to forging dimensions or eccentricity.

Descaling

The thorough heating of billets with uniform soaking heat of about 2300 deg. F. in a rotary or pusher type furnace and the descaling of the billet after it leaves the furnace is an important item. Several methods for descaling are in use. One method employs a fine stream of high pressure water on all 4 sides, while the billet passes from the furnace to the piercing die.

Another method is to push the billet by means of a small hydraulic cylinder through a set of descaling rolls. These rollers squeeze the square billets on the 4 corners, thus loosening the scale on the sides of the billets. Also an arrangement of wheels with sharp teeth mounted in a box structure, engaging the 4 sides of the square billet, is sometimes used to crack and remove this scale.

Whichever method of descaling is employed, descaling by hand to remove the last particle of scale should be done.

Cooling and Lubricating of Tools

The cooling and lubricating of the piercing and drawing tools is another important item.

Drawing mandrel can readily be arranged for inside cooling by circulating water under pressure inside the mandrel. A mandrel that is hotter on one side than on the other because of improper outside cooling will produce a bent shell forging (banana shape) after the shell is stripped from the mandrel.

The means of stripping the shell from the drawing mandrel must be seriously considered. A good self-adjusting stripper arrangement will prevent the irregular edge at the mouth of the shell from upsetting. An upset edge interferes when entering the shell into the fixture of the sand-blasting equipment at the shell machining shop.

In some cases it is necessary to cool slightly and descale the inside bottom of the pierced shell. This is done either with a hot water spray or steam jet. Such cooling prevents deforming of the bottom of the shell, which may be caused by the drawing mandrel's pushing against it, and thus producing thin bases of the shells. A chip of wood placed inside the hot

Table 1.—Suggested Billet and Forging Sizes

Shell Size	Billet Weight, lbs.	Billet Dimension (if square)			Pierced Forging		Finished Drawn Forging		
		Across flats	Across round corners	Length	Outside diameter	Length	Outside diameter	Length	Largest inside diameter
U. S. 75 mm.	20.2	3 1/32	3¾	8⅝	3¾	9 5/16	3.28	13.86	2.13
Brit. 18 lb.	24.1	3½	4¼	7⅜	4¼	7⅜	3.29	10	1.89
U. S. 90 mm.	36.6	3½	4¾	11	4¼	12	3.92	14½	2.55
Brit. 25 lb.	37	3½	4¼	11	4¼	12	3.7	15¾	2.17
Brit. 3.7 lb.	39	3¾	4½	10	4½	12	4	15¼	2.43
Brit. 4.5 lb.	47	4½	5.56	8¾	5.56	10¾	4.875	15¾	3.45
U. S. 105 mm.	49	4½	5½	9	5	10¼	4.55	17⅞	3.3
Brit. 60 lb.	99.5	5½	6½	12¼	6½	12¼	5.50	18 5/16	3.04
Brit. 6 in.	160	6¼	7¾	14¾	7¾	16	6¼	26 5/16	4.17
155 mm.	142	6½	8	12⅜	8	14⅝	6⅜	26¾	4.95
7.2 in.	230	7¼	9½	18	9½	22	8	32	6
8 in.	310	7½	10¼	22	10¼	25	8.6	37	6.47
9.2 in.	366	8¼	10½	19 7/16	10 11/16	23⅝	9 11/16	35⅛	7 5/16
12 in.	987	11	13⅞	29 11/16	15½	25⅝	12 11/16	42	8 1/16

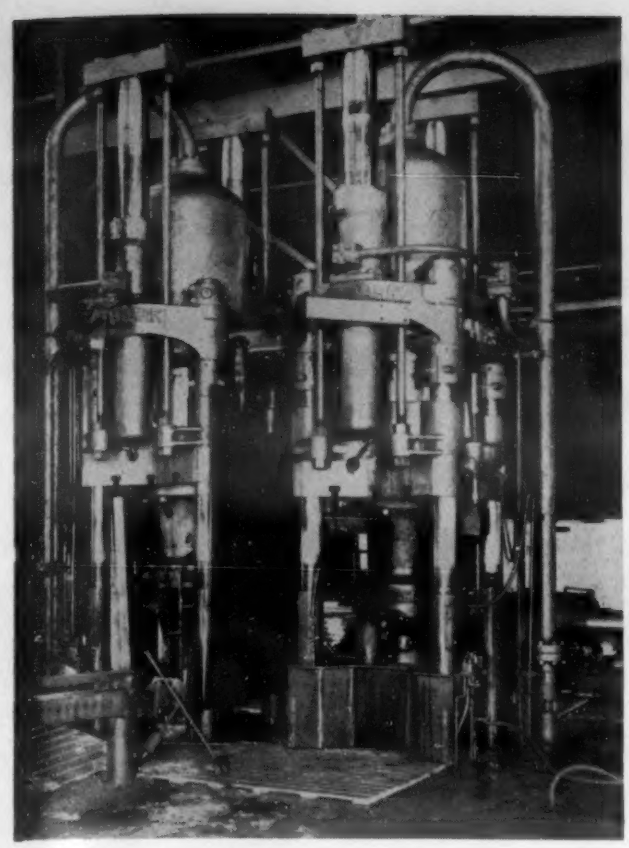


Fig. 1 Hydraulic vertical shell piercing press.

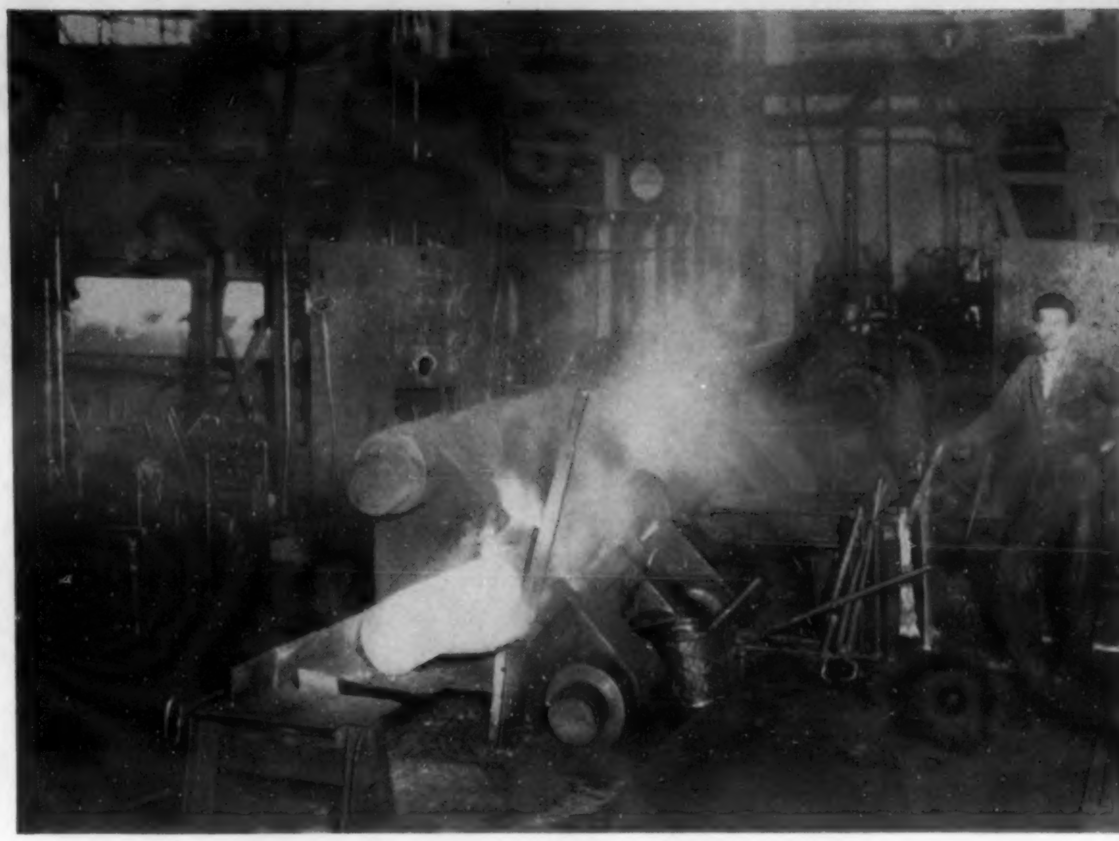


Fig. 2. Horizontal hydraulic ring type of shell drawing press.

shell after it is stripped from the drawing mandrel prevents inside scaling.

Piercing and drawing punches at all times must be kept in perfect condition and frequently redressed or renewed, so as to produce an inside cavity free of defects and to finished dimensions.

Hydraulic Piercing and Drawing Presses

For shells used in this war, several new forging methods have been devised. The oldest and most commonly used method of piercing and drawing shell forgings is on hydraulic presses, and this is still the most suitable type of equipment for forging shells larger than 6 in. and is also widely used for sizes under 6 in. Some typical hydraulic piercing and drawing presses are shown in Figs. 1 and 2.

The hydraulic piercing press is generally of the vertical, 4-column type, while the drawing press can be of the vertical type for small-size shells and of the horizontal type for large-size shells.

In this method of hydraulic piercing a square billet can readily be used. When using square billets less power is consumed in the piercing operation, because the square billet is expanded into a round cup in the round piercing pot. A small amount of extrusion over the piercing punch takes place, thus saving wear on the punch and power to operate the press—all of which is reflected in the cost of the forging. Figs. 3 and 4 show sections of 75-mm. and 6 in. shell forgings, and Fig. 5 demonstrates the metal-flow in the shell forging operation.

For the 6-in. shell a billet 6¼ in. square measuring 7¾ in. across round corners, 12⅜ in. long is pierced to 7¾ in. diam., 16 in. long. This shows that the billet is more expanded than extruded. The pierced billet is reduced in the drawing press to 6⅝ in. outside diam. and drawn to a length of 26-5/16 in.

On the 75-mm. shell the billet is 3-1/32 in. square, 3¾ in. across corners, and 8⅝ in. long. Pierced, it measures 3¾ in. outside diam. and 9-5/16 in. long; and when drawn, 3¼ in. in diam. and 14 in. long.

The hydraulic press method of piercing and drawing is applicable to all sizes of shell forgings from the smallest to the largest. Also, the rate of production compares favorably with any other method when compiling the cost of acceptable shell forging, particularly as to saving in cost of tools and equipment.

The piercing speed should be about 14 in. per

Table II.—Suggested Press Capacities

Size of Shell, in.	Operation	Capacity of Press, tons	Stroke
3	Piercing	200	30 in.
3	Drawing	75	68 in.
4.5	Piercing	300	36 in.
4.5	Drawing	125	84 in.
6	Piercing	500	46 in.
6	Drawing	200	10 ft., 6 in.
8	Piercing	700	50 in.
8	Drawing	220	12 ft.
9.2	Piercing	1000	60 in.
9.2	Drawing	260	14 ft.
12	Piercing	1500	72 in.
12	Drawing	340	20 ft.

sec. and the drawing speed about 20 in. per sec. Such speeds will give the metal in the forging a chance to flow at a proper speed and keep the tools in contact with the hot metal as short a time as possible so as to prevent overheating of the tools.

Shell Forging Tools

Inside water-cooling of piercing and drawing mandrels will prolong their life and surface finish. The latter is essential in this final forging operation to obtain a perfect finished cavity.

Before the piercing punch enters the hot round billet an upsetting punch is first used which squeezes the billet tightly into the piercing pot, thus filling the latter, and at the same time providing a round center punch impression on the top of the billet.

When using this method, which is also applicable on square billets, both the upsetting punch and piercing punch are attached to a sliding punch holder. Such a sliding punch holder arrangement will permit the piercing punch to be immersed into an oil tank located alongside the piercing pot while the upsetting punch is in operation on the down stroke of the press.

A recent development in piercing tool design is the inverted method of piercing, as illustrated in Fig. 6. With this method the piercing pot is attached to the

Fig. 3. Steps in the manufacture of a 75-mm. pierced and drawn shell forging.

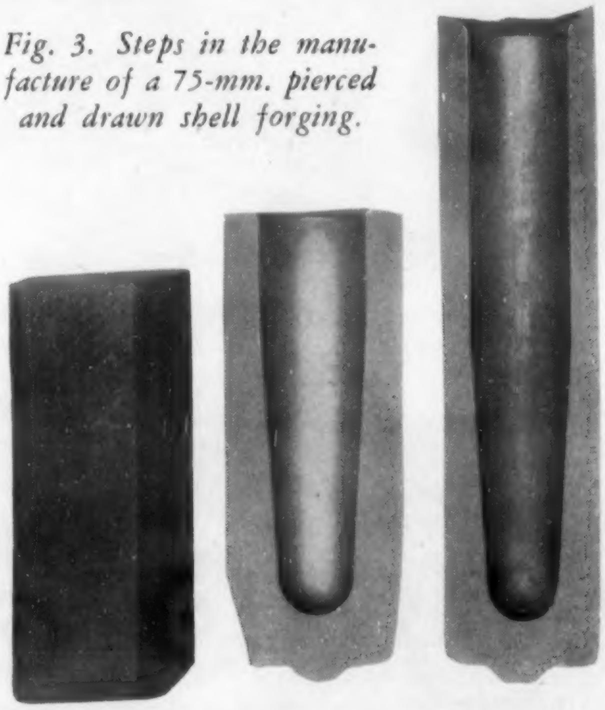


Fig. 5. Edged section of shell forging with soft wire inserted at intervals in the billet, showing the flow of metal during the forging operation.

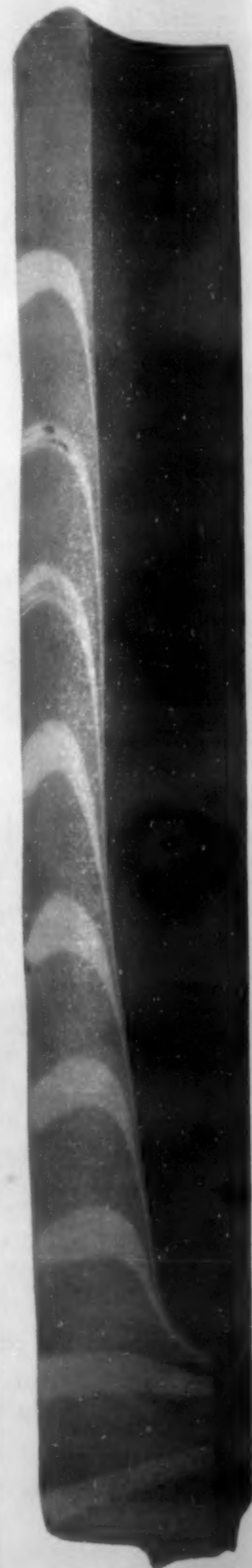
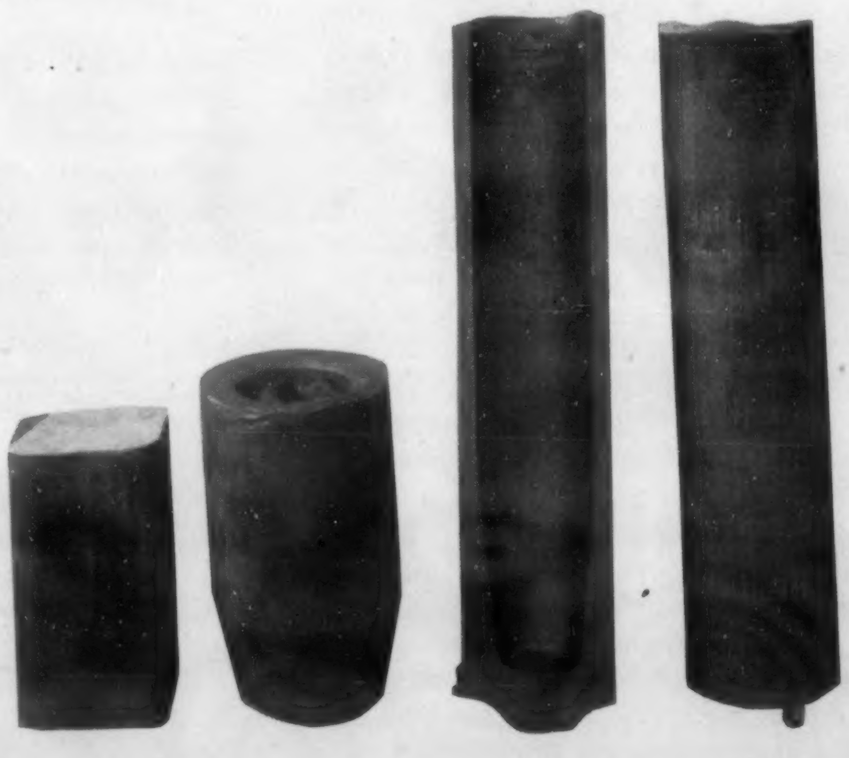


Fig. 4. A 155-mm. shell forging, made in 2 operations. On the square billet the dark triangular section shows the amount of gas nicking; the light surface shows the clean and square break. The pierced shell is slightly longer than the billet. The drawn shell has been elongated by drawing through 4 rings.



moving platen of the downward-moving press, while the piercing punch is attached to the stationary press bottom platen. This type of die arrangement can also be used on existing old hydraulic presses of the moving-up type where the press top platen is stationary and the lower moving platen rises. On these moving-up type presses the piercing pot on the top is stationary, while the bottom piercing punch moves upward.

The hydraulic shell drawing press design also has been improved recently. Instead of using the conventional ring dies in the drawing die heads, a set of 4 rollers in each draw head is used. This arrangement is shown in Figs. 6a and 6b.

In this roller type of draw head the metal of the pierced forging is rolled over the drawing mandrel, thus reducing the shell in diameter and elongating it to its finished dimensions; in this set-up less friction is created in the dies and less power is required to operate the press. A record of over 150,000 shells drawn with one set of roller dies in the die heads has been established.

Other Hydraulic Piercing Presses

The United Engineering and Foundry Co. is manufacturing the United Turret Type Hydraulic Piercing Press, which can be used in conjunction with either square or round billets in sizes up to 155 mm. shell forgings, producing about 200 shells per hr. of 155 mm. size and more on smaller sizes.

This press is of the 3-column type with an internal packed, double-acting cylinder on top. The moving platen carries a turret to which are attached four piercing punches.

The bottom platen of the press also is equipped with a turret carrying 4 piercing pots. With this turret arrangement using 4 complete sets of dies, each die set when making 200 forgings per hr. will come into actual piercing operation only 50 times, thus prolonging the die life. All turret motions are automatically interlocked.

The pierced forgings then are passed on to a shell drawing press for the final operation.

This same company also is the licensee in this country for the manufacture of the "one-shot" press. The principle of this press is to make a finished shell forging in one operation ready for machining. In this press the piercing punches are attached to a rotating turret. The square billet is placed in a split die. (See "United Effort," Feb. 1941.)

Mechanical Upsetting and Forging Machines

The forging of shells by the upset method for shells up to 6 in. is accomplished in the horizontal forging or upsetting machine, which is a mechanical, motor-operated forging unit (see *The Iron Age,* Vol. 147, Jan. 16, 1941, page 25). Machines of this type

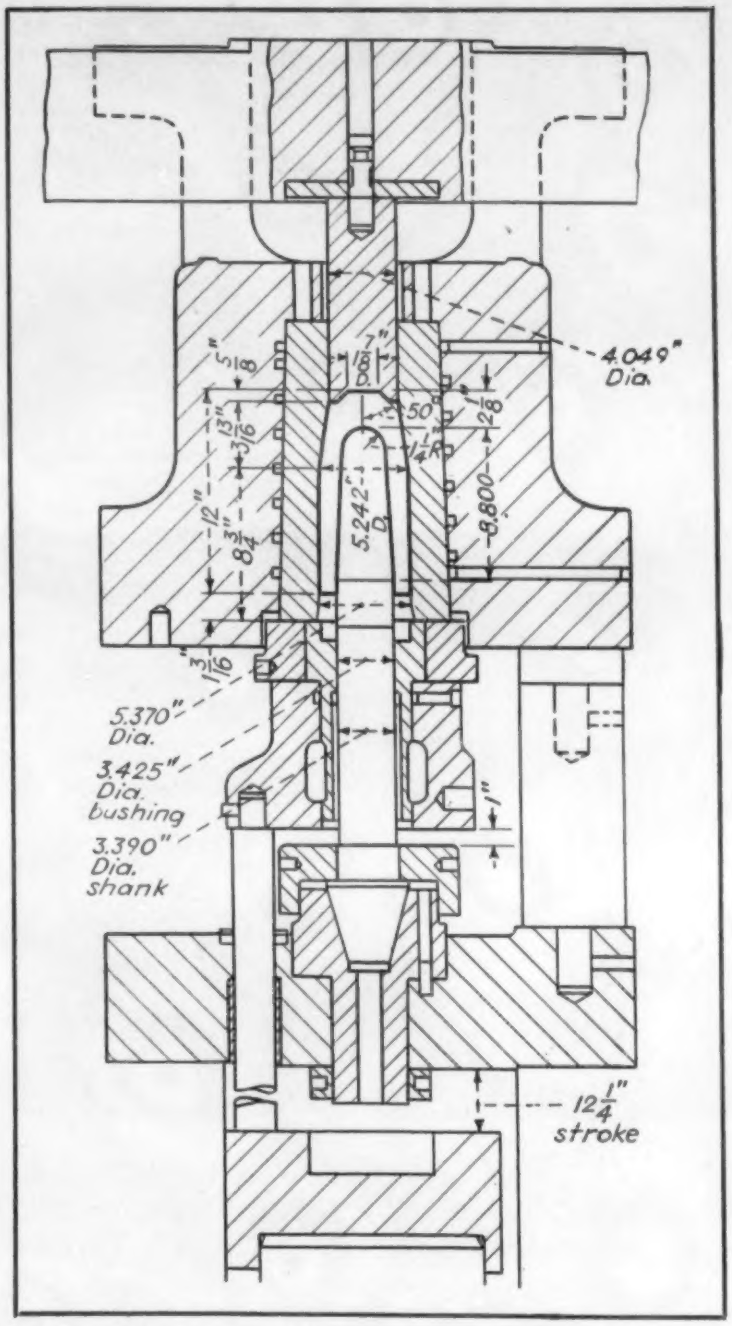


Fig. 6. Piercing tool design for the recently-developed inverted method of piercing.

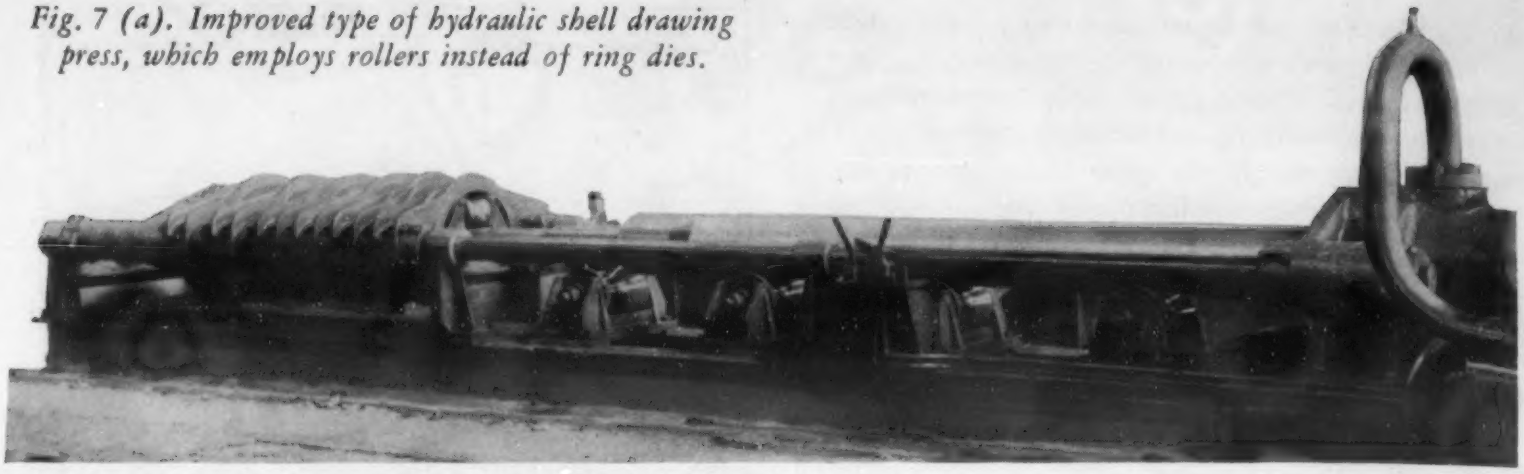
are built by the National Machine Co., Tiffin, Ohio; the Hill Acme Co., Cleveland, and the Ajax Manufacturing Co., Cleveland.

On these machines, up to 5 operations with 5 strokes of the machine are required to make a complete forging. The crosshead carries 5 punches, one for upsetting the steel bar in the first operating stroke, while during the other 4 strokes the steel bar is successively pierced. In this piercing operation the metal is also expanded by the piercing punches. The round bars are smaller in diameter than the outside diameter of the finished forging.

The split die carries 5 cavities. Each cavity is of such shape as to allow for the progressive expansion and depth of cavity. The steel bars are cut in length so that 2 forgings are made from one bar.

After one shell forging from one end of the bar has been completed, the other solid end of the bar

Fig. 7 (a). Improved type of hydraulic shell drawing press, which employs rollers instead of ring dies.



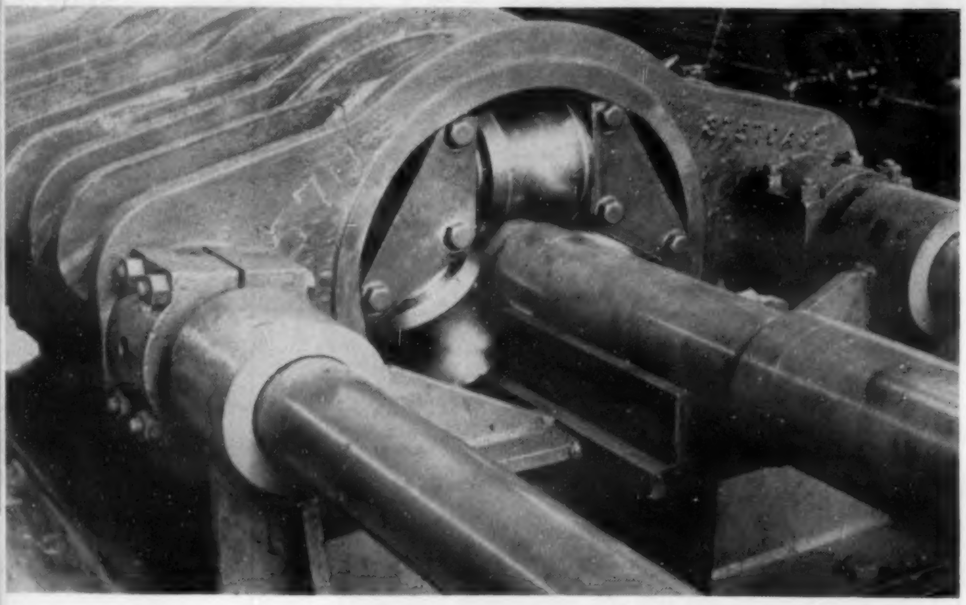


Fig. 7 (b). Close-up view of the 4 rollers used in the drawing die heads of the hydraulic press shown in Fig. 7 (a)

is reheated and forged. The first forged shell on this bar serves as a tong hold. It is also possible to use long bars, forging only one shell from the end of the bar, cutting off the finished forging, reheating the bar for the next shell, and so on until the last portion of the long bar is forged into a shell. As each of the 5 piercing tools performs only a partial piercing operation, the wear on the toools is very light. Approximately 7,000 operations, and more, can be obtained from these 5 tools.

Mechanical Piercing and Drawing Machine

The Baldwin-Omes mechanical shell forging machine, manufactured by Baldwin Southwark Div., Philadelphia, produces a forging on the same principle as in the hydraulic press method—that is, by piercing and drawing shells up to 6 in. size.

For shells up to 105 mm., this is a combination piercing and drawing machine, operated from a 125-h.p. motor. The piercing and drawing tools are operated from the main shaft. The machine is shown in Fig. 8. The piercing part of this machine is similar to the conventional upsetter construction but accomplishes the piercing operation in one single press stroke; the drawing portion of this machine, which is an integral part thereof, draws the pierced forging through the draw rings simultaneously with the piercing stroke.

This machine has a speed of $7\frac{1}{2}$ strokes per min. but for good forging reasons every other stroke of the machine is utilized, thus making 3 shells per min. Split dies, as illustrated in Fig. 9, contribute to the high production rate and die life of these machines.

Bulldozers

During the last war, many shells were made on a horizontal bulldozer. With improvements, this type of machine (manufactured by Williams, White & Co., Moline, Ill.) is used at this time for making 75-mm. shell forgings; it is ordinarily driven by a 75-h.p. motor. On the vertical projections, or back stop of the bulldozer are mounted 2 forged steel cup blocks, each containing 3 bored holes lined with cylindrical cast iron renewable liners. Between these 2 blocks is mounted a drawing bolster with 2 positions, side by side, bored with tapered holes for the drawing rings.

The drawing bolster has foot-operated strippers and at the back of the bolster are spring-supported stamp holders for stamping initials and code numbers to identify the mill and heat number of the steel. A cast steel ejector bar is located back of each cup block and carries steel or alloy ejector pins which form the bottom in the case of the shell and in the No. 3 position to determine the base thickness together with the bottoming mandrel in that position. These ejector pins are operated by pull rods attached to the mandrel holders on the crosshead so that on the return stroke of the crosshead the work in each cavity is brought forward for the operator to make the pass to the following operation.

Opposite the cups on the crosshead are 2 mandrel holders, one on each side of the machine, containing upset, pierce and bottoming tools, and one in the center for the 2 drawing mandrels. Two stripper

plates attached by 4 long bolts to the cup blocks are carried forward on the forward stroke of the crosshead and returned by springs on the return stroke, with their travel stopped by the bolt heads. Holes through these permit the mandrels to travel back and forth, but strip the forgings from the mandrels should they ride out on the mandrels in the No. 2 and No. 3 positions instead of remaining in the cups. With new mandrels, the first few shells tend to cling to the mandrel, but after that only an occasional shell fails to remain in the cup to be ejected by the ejector pin.

The piercing, bottoming and drawing mandrels are internally cooled by a water hole drilled from the butt to within 1¼ in. of the tip. A tube somewhat smaller than the water hole is inserted, which does not quite bottom in the water hole. Water is fed with a hose connection to a manifold on the crosshead, which introduces water into the mandrel sockets and thence into the tools, through the tube, the water being wasted through vent holes just outside the mandrel sockets into a pit below the machine.

Four operators on an insulated wood platform on top of the stationary dies feed the billets through the 4 passes, thus completing a shell in the central drawing position.

A production as high as 300 shells per hr. has been obtained. The machine runs continuously. For 75-mm. shells, 3¼ in. round billets are used. Most of the work is done in the piercing operation, thus leaving very little work for the drawing operation.

Shell Rolling Mill

The principle of the Assel shell rolling mill (described in *The Iron Age,* Vol. 148, July 3, 1941, page 51) is based on that of the cross-rolling mill used in tube mills.

The first operation in producing a shell forging by this method consists of piercing either a square or round billet in a hydraulic piercing press or mechanical upsetter. Steam or drop hammers have also been recommended for this piercing work, which produces a large outside diameter but a short cup, ready for the second reducing operation in the Assel mill.

The 3 cross rolls in this mill reduce the outside diameter of the forging and elongate it over the inside mandrel. This mandrel conforms to the finished inside dimensions of the shell forging.

In the third stage of this process, both the hot-rolled shell and the loose mandrel inside are then removed from the rolling mill and placed in a sizing or drawing bench located alongside this rolling mill. This sizing bench, by means of a hydraulic ram, pushes the rolled forging and mandrel through a sizing die head which could be either of the roller or ring type. The double-acting sizing ram on the return stroke strips the finished forging from the mandrel, as the mandrel inside the shell during the rolling operation remains inside the shell until it is stripped and after it passes the final sizing press. Several inside mandrels are required so as to keep a constant supply in the state of cooling in an oil bath.

The operation of this rolling mill is very fast and requires several piercing press units or specially designed multiple-stage turn-table type piercing presses with pumps and accumulators.

Production

It is not a question of how many shells per hr. can be forged on a unit, but how many perfect forgings with finished cavities at the least tool expense and die upkeep can be produced at an average hourly rate of production during a day's run.

Also, the endurance of the operator is to be taken into consideration. A crew handling 300 hot billets, weighing approximately 20 lbs. each per hr. for 3 in. shells, or 160 billets per hr. weighing 140 lbs. each for 6 in. shells, would have to handle 6,000 to 22,000 lbs. of steel per hr. with either mechanical or hand-lifting devices. Rest periods during each shift, therefore, are required, necessitating 2 crews for 1 forging unit per shift.

The final cost of shell forgings comprises the cost of steel billets, the nicking and breaking, the cost of heating the billets, plus wages of crew and cost and upkeep of tools, plus overhead expenses, percentage of rejections and amortization of equipment.

To produce perfect forgings at a high rate of production, it is very important that the hot finished forgings are checked for length, base thickness and concentricity at short intervals, as they pass on to the cooling bed. This frequent checking will detect any misalignment in machine and tools, faulty tool

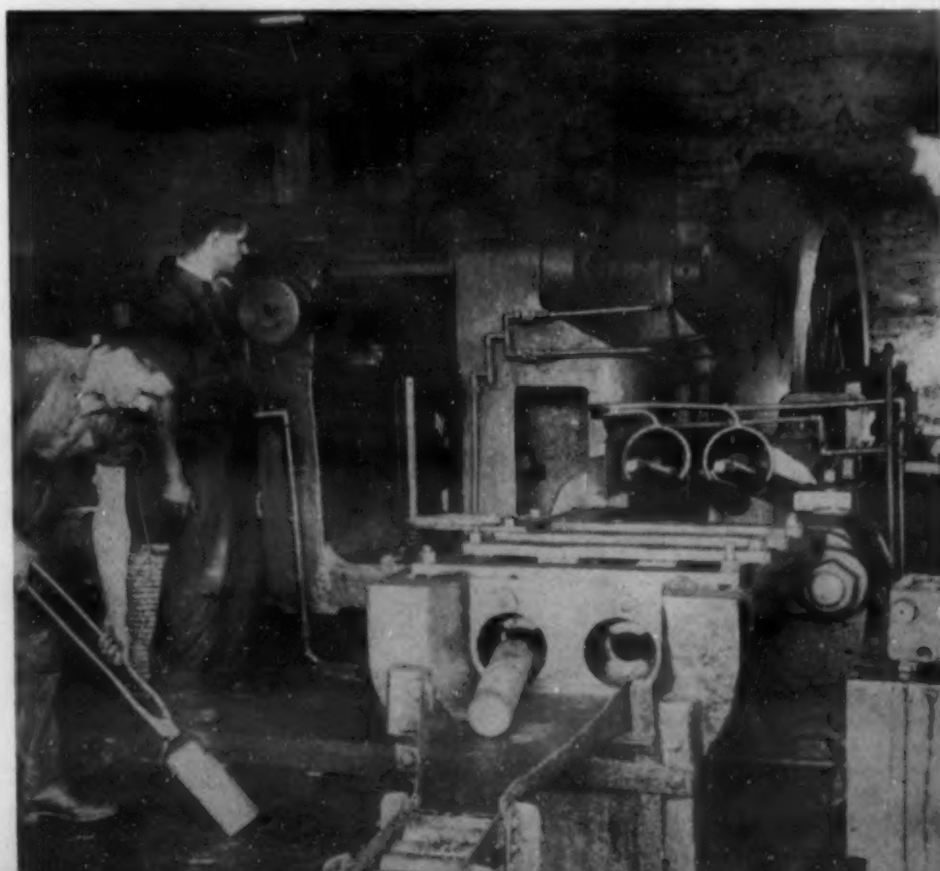


Fig. 8. Baldwin-Omes mechanical shell forging machine.

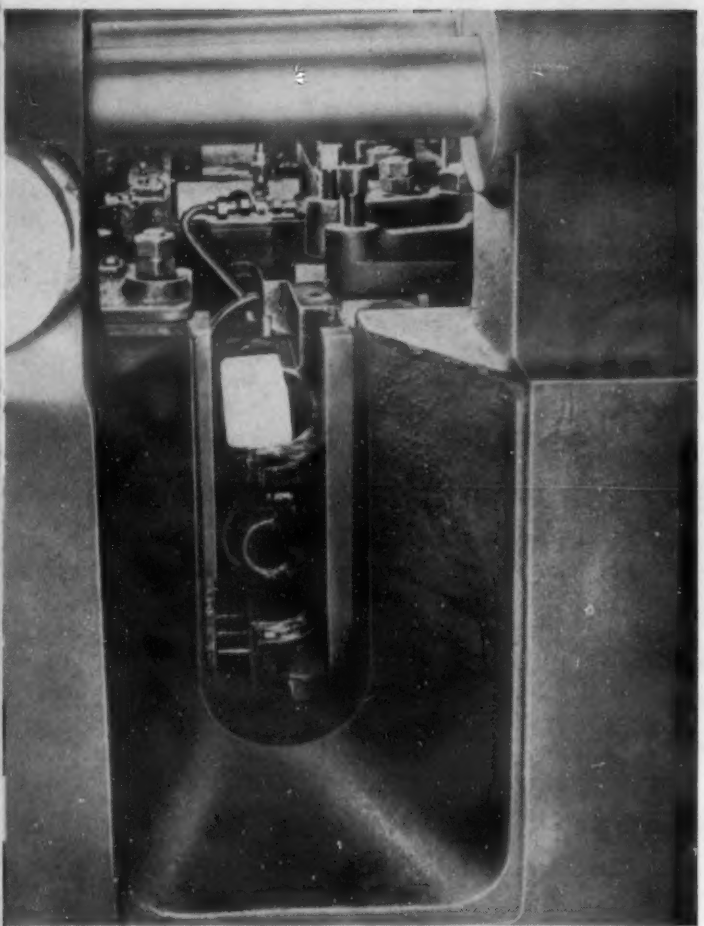


Fig. 9. A hot billet in the split dies on the Baldwin-Omes machines.

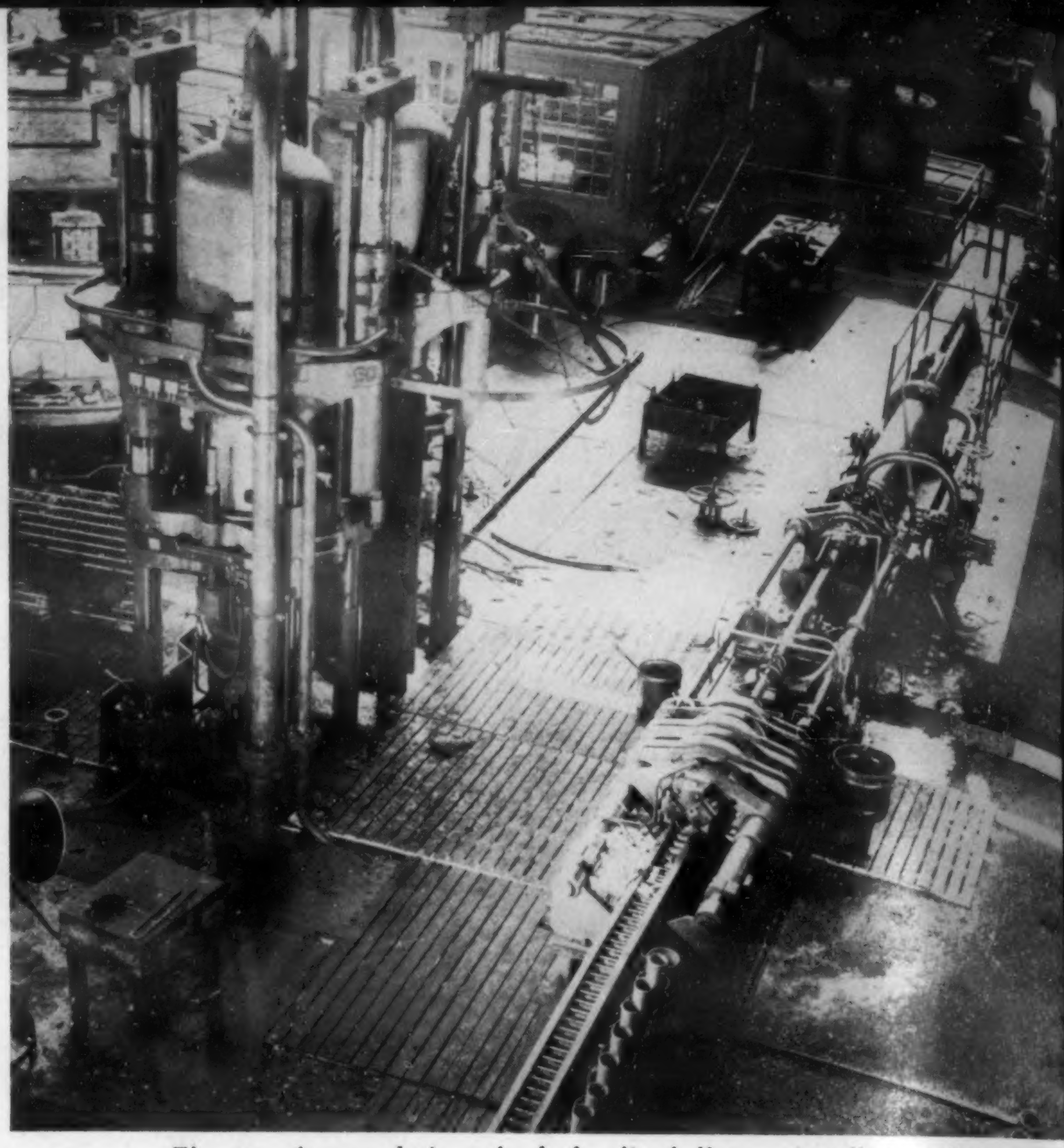


Fig. 10. A general view of a hydraulic shell press installation, showing 2 hydraulic piercing presses and 1 horizontal drawing press.

cooling and tool lubricating conditions, pitting or scoring caused by excessive scale on billets, etc.

The average hourly production on various types of shell forging equipment varies, as the following typical cases indicate.

On a recent hydraulic press installation (shown in Fig. 10) consisting of 2 piercing presses with inverted piercing dies and one 3-ring type of horizontal drawing press on 75-mm. shells, heated in a rotary furnace, the average hourly production was 210 shells per hr., production on 105-mm. shells was 150 per hr., but can be increased about 30 per cent with additional high pressure pumping capacity and furnace capacity.

Another hydraulic press unit with one piercing press and one drawing press with mechanical handling devices produced 155-mm. shells at an average production of 160 per hr. with 3 men on the presses and 3 men at the furnace. Seven additional helpers for lubricating tools, stamping the shells, operating turn tables and running conveyors were employed, or a total of 13 men per unit. The same number of men are operating a Baldwin-Omes shell forging unit producing 159 105-mm. shells per hr. with a 125-h.p. motor. On 9.2 in. shells with one hydraulic piercing press and one hydraulic horizontal drawing press, 50 shells per hr. weighing 366 lbs. each were produced. This figures 18,300 lbs. of steel per hr.

With the Assel mill's high speed rolling operation and an adequate number of piercing presses or upsetters, it is stated that the average hourly production was 250 shells during an 8 hr. run and 235 per hr. average on a 24-hr. run on 75 mm. shells, requiring 300 h.p. on the Assel mill.

On a bulldozer the average production was 160 per hr. with 4 men on the machine feeding the dies.

The upsetter or forging machine with a 5-operation die is said to produce from 65 to 75 shells of 75 mm. size per hr. requiring 60 h.p. motor and a crew of 7 men.

The United type piercing press with turret type piercing tools is stated to produce 275 75-mm. shells with 200 tons press capacity, 250 90-mm. shells on a 270-ton piercing press, 225 105-mm. shells on a 320-ton press, and 200 155-mm. shells on a 400-ton press which will require additional drawing presses to complete the process.

Die Life

On a hydraulic press installation for 155-mm. shells an average of 800 shells for piercing and drawing punches and 3,100 shells per set of drawing rings has been reported.

On the Baldwin-Omes shell forging machine (dies illustrated in Fig. 11) actual production showed die

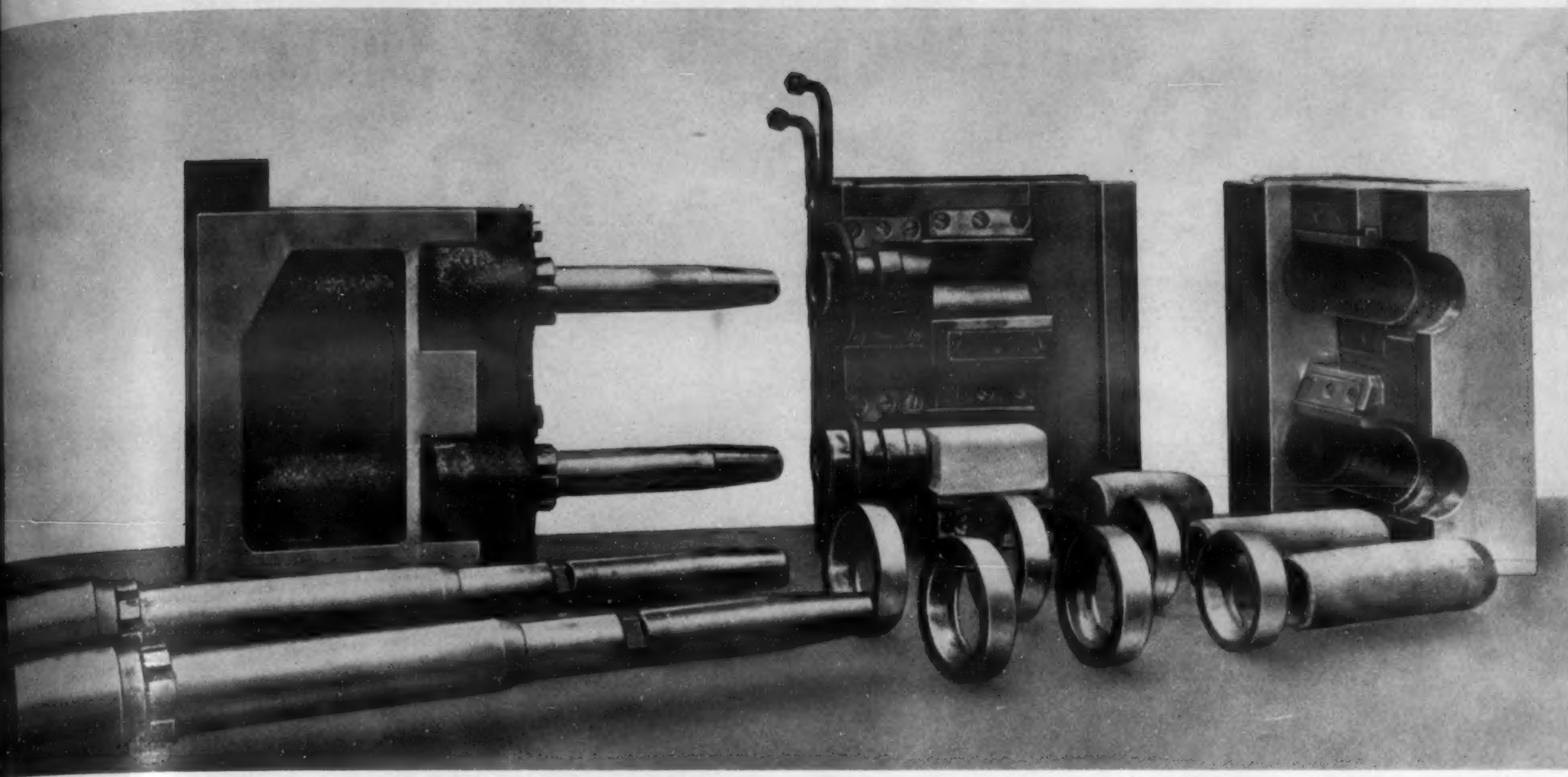


Fig. 11. Piercing and drawing dies for horizontal Baldwin-Omes forging machine.

life on 105-mm. shells as follows:

Piercing punches	8,000 shell forgings
Half die liners	10,000 shell forgings
Drawing mandrels	6,000 shell forgings
Drawing rings	10,000 shell forgings

When making this number of forgings with one set of tools, it is necessary, of course, to redress the tools after making 3,000 to 4,000 forgings.

On a hydraulic roller type draw press, one set of rollers (4 each in the 6 heads) produced over 150,000 6-in. shells.

On an upsetter with 5 tools it is reported that up to 20,000 small forgings with one set (or 4,000 forgings per tool) and up to 5,000 to 6,000 larger forgings (or 1,000 per tool) can be produced. Tool steel specifications should be suitable for the type of forging equipment and size of shell. Most shell forgers have experimented with several types of tool steel and are in a position to make such `recommendations.

Forging Methods of Various Companies now Making Rifled-Bore Shell Forgings

American Car & Foundry Co.	Southwark Hydraulic Piercing & Drawing Presses
American Forge Div (American Brake Shoe & Foundry Co.)	Mechanical Upsetter
Baldwin Locomotive Works	Baldwin-Omes Mechanical Piercing & Drawing Machine
Budd Wheel Co.	Mechanical Upsetter
Colorado Fuel & Iron Corp.	Elms Hydraulic Piercing & Drawing Presses
Crucible Steel Co.	Hydraulic Piercing & Drawing Presses
International Harvester Co.	Mechanical Upsetter
J. I. Case Co.	Southwark Hydraulic Piercing Press with Case Rotary Single Operation Dies
Kilby Steel Co.	Southwark Hydraulic Piercing & Drawing Presses
Lansdowne Steel & Iron Co.	Southwark Hydraulic Piercing Press & Hydraulic Roller Type Draw Bench. (Lansdowne Type)
Moline Forge, Inc.	Williams, White Bulldozer with Multiple Die
National Supply Co.	Southwark Piercing & Drawing Presses
National Tube Co.	Hydraulic Piercing and Assel Mill
Pittsburgh Forgings Co.	Upsetter & Assel Mill
Pittsburgh Steel Co.	Baldwin-Omes Mechanical Piercing & Drawing Machine
Pressed Steel Car Co., McKees Rocks, Pa.	Baldwin-Omes Mechanical Piercing & Drawing Machine
Pressed Steel Car Co., Hegewisch, Ill.	Baldwin-Omes Mechanical Piercing & Drawing Machine
Pullman Standard Car Mfg. Co.	Southwark Hydraulic Piercing & Southwark Hydraulic Roller Drawing Press
Taylor-Wharton Iron & Steel Co.	Hydraulic Piercing & Southwark Hydraulic Drawing Presses
Tennessee Coal & Iron Co.	Piercing & Drawing Presses
Tube Turns, Inc.	Mechanical Upsetters
Willys-Overland Motors, Inc.	Elms Hydraulic Piercing & Drawing Presses

Plastics and Metal Shortages

by HERBERT CHASE

The subject of plastics and their effect on metals is a very active one, especially as to the possibility of their replacing metals. Mr. Chase discussed this in our April, 1940, issue. In this article he reviews the present situation which has changed quite decidedly since last year, and discusses the extent to which plastics may ease certain shortages in metal supplies.

Mr. Chase's opinion is that plastics can be applied to ease, in some degree, shortages of certain metals —aluminum, magnesium, zinc and others. And he tells how and why.—The Editors.

IN APRIL OF LAST YEAR, the present author gave, in METALS AND ALLOYS, his answer to the question, "Will Plastics Displace Metals?". In essence, he concluded that, although plastics may displace metals on a limited scale, under certain specific and unusually favorable conditions, any wholesale substitution appeared unlikely, plastics being supplementary to rather than substitutes for metals except under a few conditions not having broad significance.

Much has happened since that time and the defense economy, under which this Nation is operating as this is written, is a very different economy from that which existed when the first article was prepared. Should this country be involved in actual war by the time the present article goes to press, the resulting economy promises to be changed still further. Nevertheless, the writer contends that his conclusions reached in the earlier article are still entirely justified. Certain conditions have changed, but the inherent characteristics of materials naturally remain unaltered.

It is true, however, that when a shortage in any given material occurs it is sometimes mandatory that another be found to take its place, even though costs may be higher and results attained are inferior. In the case of such relatively new materials as plastics, new methods of using them to advantage, where they were inadequate or unsuited before, are introduced or become feasible every few months. Certain developments of this nature have occurred in recent months and appear quite certain to have some effect on the situation as a whole.

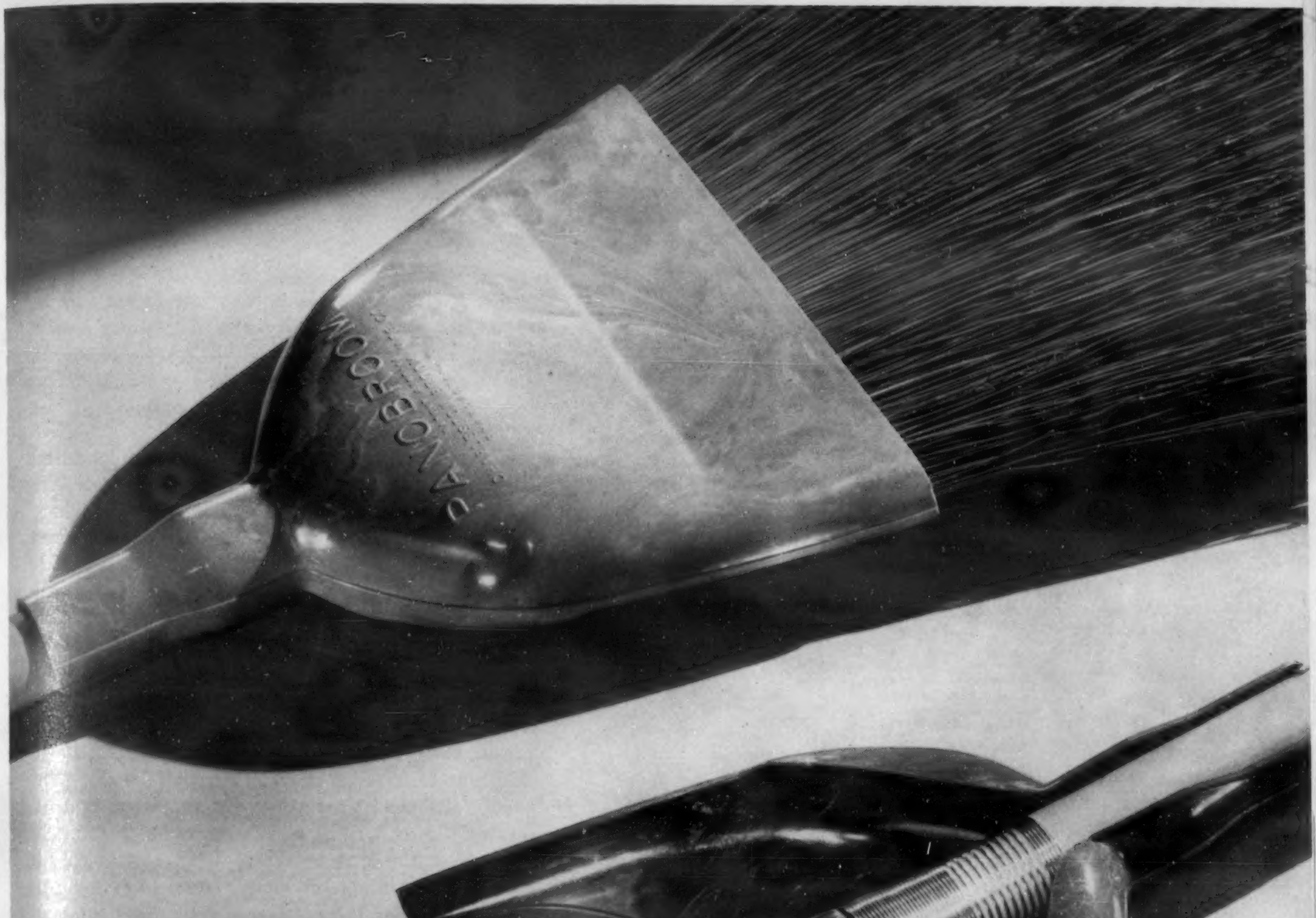
When, as at present, there is a shortage of such highly important metals as magnesium, aluminum and zinc (among others which need not be mentioned here), any feasible substitutes which may ease the situation in a significant degree deserve attention and patriotic engineers who may be concerned are bound to give them study. It is a credit to those in authority in the O.P.M. and in other Government agencies that such studies in reference to plastics have been ordered or encouraged. They and others with industrial experience realize that a shift from metals to plastics, insofar as it may be feasible at all, cannot be brought about over night. Where it can be accomplished at all, some period for investigation and test must be allowed if assurance of helpful results is to be had.

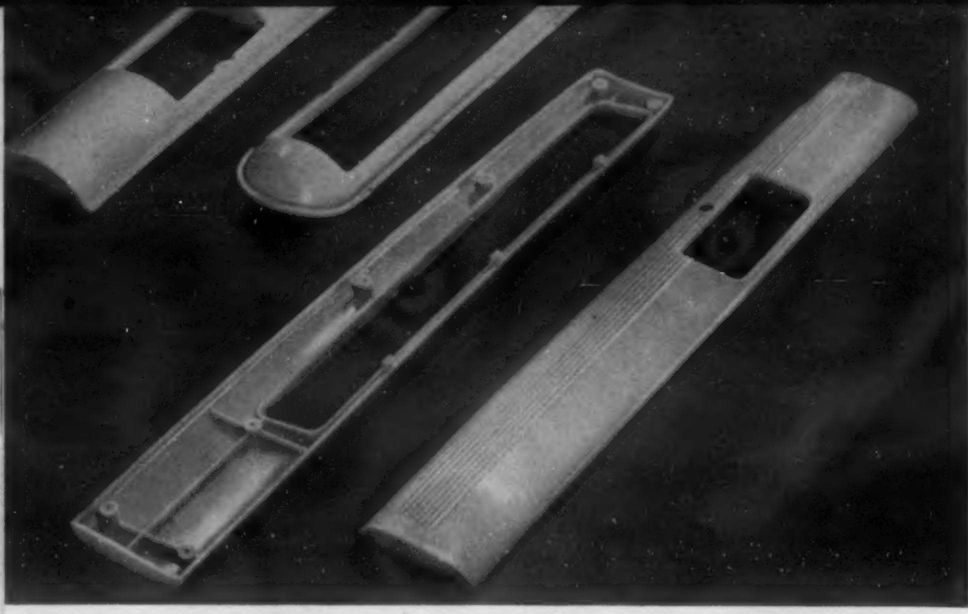
The Present Problem

The question now is, "Can plastics help to ease any metal shortages and, if so, how and to what extent?" It is the author's view that plastics can be applied to ease, in some degree, shortages of magnesium and of aluminum, but how soon, or to what extent, it will almost certainly require several months at least to determine. As to zinc, the effect of possible uses of plastics appears much less promising and of relatively small moment, though not, perhaps, insignificant. Reasons for these conclusions will shortly be given. There may be some effect upon other metals but, as far as the author can now see, it is likely to be a minor one and will not be considered here.

As here considered, the term "plastics" is taken to

This dust pan which fits over a broom is injection molded from Tenite, being light, smooth, colorful and easy to clean. This is not a direct substitution of plastic for metal, yet most dust pans have been metal heretofore.





TOP

Acetate-butyrate plastic (Tenite II) is being used by Ford for automobile instrument panel moldings such as these, but the base panel is of steel. Zinc alloy die castings were used formerly for similar, though not identical, parts.

CENTER

Most makers of domestic washing machine agitators now have them molded from a special grade of Bakelite where aluminum alloy permanent mold castings were used almost exclusively before, but some shortage of plastic for this purpose is already reported.

BOTTOM

Extruded shapes produced from thermoplastics, as here shown, are being substituted for similar shapes formerly made from aluminum and from other metals. In aircraft, some extruded plastic tubing has taken the place of aluminum wire conduits.

include many synthetic substances commonly called plastics, as well as the resins which constitute the binders in plastics even though used, strictly speaking, as substances for impregnation and/or as adhesives rather than for the ordinary forms of plastic molding. Rubber, though the most important of all plastics, is here left out of consideration as are also the artificial rubbers and rubber-like substances, as to include them, with adequate explanations would lead to complexities already too plentiful.

In a few instances, plastics have been applied in place of steel, but it is obvious that, when the total production of plastics is less than half of one per cent of total steel production (as the latest figures indicate) the total effect of plastics upon steel, even though the entire output were to displace steel, could not be very significant. But in relation to aluminum and to magnesium, the situation is quite different, for their output is only a small fraction of that in steel and not so far from that of plastics. It follows that, if a large proportion of plastics can be used to replace magnesium or aluminum, the effect on the supply of these metals might be significant. The following table makes this clear:

Approximate Production of Certain Metals and of Plastics in 1939

Steel	81,210	million pounds
Zinc	1,252	million pounds
Aluminum	327	million pounds
Magnesium	12½	million pounds
Plastics	160*	million pounds

* Precise figures on plastics production are lacking but estimates range from about 160 to 250 million lb.

As far as the author can foresee, the only way in which plastics can have any very significant effect upon the zinc situation lies in the possible substitution of plastic moldings for zinc alloy die castings. Even there, there is little to indicate that the substitution can be very extensive.

Thermoplastics

It is true that injection molding of thermoplastics (the cold setting type) is similar to die casting and that, as far as shape is concerned, many die castings can be duplicated by injection molding. But when the properties of the two types of materials are compared and relative costs are considered, it becomes apparent that the substitution can rarely be made *except* for parts which are for decorative purposes or in which the stresses are relatively light. Even then, a combination with metal parts is commonly required to reinforce the plastic, to prevent it from warping or to compensate for dimensional changes which occur in aging. Besides, cellulose acetate, the plastic most used for injection molding, is not suited for outdoor exposure and those types which are suited are still more expensive. Moreover, injection molding is now limited to parts not exceeding 2 lbs. in weight. There is, too, considerable doubt as to any very significant increase in the quantities of thermoplastics which can be produced under existing conditions.

Much the same can be said of thermo-setting plastics (the hot setting type) except that they are, in the most used phenolic varieties, lower in cost than the thermoplastics, and are not, at present, commercially produced by injection molding although, as this is written, some machines for injection molding them are reported as just emerging from the development state. Nearly all molding of heat-setting plastics is now done with powders or preforms in compression presses under a rather slow cycle, ranging, in general, from about 1 min. minimum for certain small parts, up to 10 min. or more for large moldings. The heat-setting plastics, as a class, are quite brittle and, although they can be strengthened by the addition of fibrous fillers, the latter make molding much more difficult, as a rule, and even the strongest type has a tensile strength about one third that of the zinc alloy die casting and an impact strength probably not over 2 per cent as great. Some phenolic plastics can be used in outdoor exposures, but the colors are mostly dark and not light fast. Other heat setting plastics available in light and stable colors are not suited for outdoor use.

Certain savings, often important ones, can be made in finishing cost when plastics are substituted for metals and the natural beauty of many plastics is a great asset for decorative parts, but the limitations, as above indicated, greatly influence the substitution of plastics for metals for a large range of uses in which die castings, among other metal parts, have abundantly demonstrated their worth.

It is true, of course, that a considerable part of the total output of die castings is for applications in which stresses are light and decorative effects are sought. Plastics can be and are being substituted for some of these where cost is in line, strength adequate and other requirements, such as dimensional stability and serviceability under the required exposure, can be met. Thus, automotive manufacturers are using in some cases more plastic parts on instrument panels, for example. This will release some zinc alloy for other uses but will require higher tooling costs and necessitate the use of metal backings where strength and dimensional stability are essential.

Use of Steel

Glove doors, for example, will doubtless be stamped from steel rather than die cast, as many have been in the past, but plastic trim may be added for appearance sake. For external parts, such as radiator grilles, headlamp bezels, tail lamp housings, moldings and the like, relatively little plastic is likely to be employed and that for small inserts, chiefly in transparent or translucent forms where light transmission is required and metal could not be used anyway. Most of the parts just named have been in zinc alloy die cast form but, where they are replaced, steel will be used in most instances and the proportion of plastics employed will, in reality, save very little zinc alloy.

It is understood that O.P.M. has instructed car manufacturers to reduce by 50 per cent the number of pounds of zinc alloy used per car in 1942 as against 1941 models. In addition, it is certain that the total car output will be decreased by at least 20 per cent, probably much more. This will result in freeing considerable zinc for other uses but the part which plastics play in this respect will be modest, as steel seems destined to do most of the replacing. The output of zinc is constantly increasing and that freed by reduced automotive consumption will also have its effect. It remains to be seen whether the combined effect will ease the zinc shortage materially or whether increased demands for brass and, perhaps, for galvanized products will eat up the saving and the added supply of zinc.

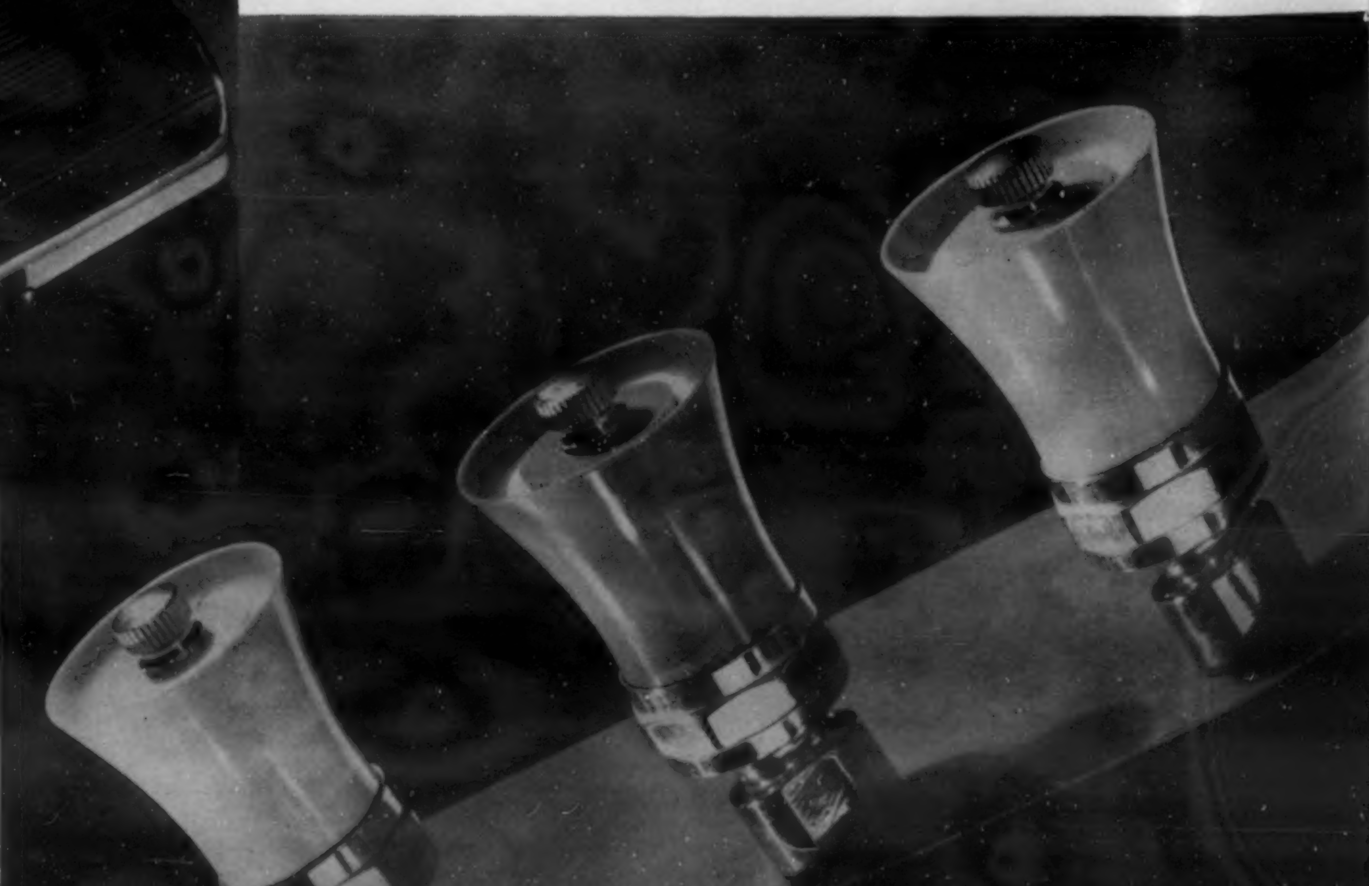
Beyond question, there will be some substitution of plastics for die castings in non-automotive uses. This will reduce in an undetermined but probably small degree the consumption of zinc alloy, but again chiefly for lightly stressed and decorative uses. It appears likely to help eliminate the use of aluminum and of magnesium alloy from all die casting applications except those for aircraft and for other war or defense needs if such elimination is not already complete. Zinc die castings may take the place of some recently produced in aluminum alloy, as the shortage in the latter is greater and more pressing than that in zinc alloy and the same dies, if made originally for aluminum or for magnesium, can be used for zinc.

When attempts to substitute plastics for magnesium or for aluminum are considered, the factors

This Bakelite housing and drawer for a cash register take the place of parts formerly made largely or wholly in metal, but there are still several metal parts. Improvement in appearance but no cost saving resulted.

Some plastic parts of shower heads take the place of metal parts but, as is common, require metal mounting portions and are only lightly stressed in normal service.

Bathroom scale in which the housing is a large injection molded frame of Tenite, not subjected to heavy stresses.



involved are somewhat different and the chances of success are increased. This is because magnesium and aluminum are employed today primarily for aircraft in which light weight is a paramount consideration and cost per piece definitely secondary. It is possible, for example, at least in some cases, to substitute a laminated-molded cable sheave for one die cast in aluminum alloy, as the stresses involved are moderate, and, if dimensions remain the same, weight will be decreased. Probably the plastic sheave will cost considerably more, as the cable groove and locking slots or openings will have to be machined and the cycle of production is much slower. The same would apply to a sheave of plastic substituted for one in magnesium except that there would be less saving in weight and no finish (or pickling) would be required. Where stresses are extremely light, certain plastic parts molded from powders can take the place of magnesium or aluminum castings providing shapes are suitable for molding and the part not too large. This might apply to instrument bezels, to cite one example.

Plastics for Wrought Aluminum or Magnesium

When it comes to substituting plastics for wrought aluminum or wrought magnesium, another set of conditions apply. In general, the plastic part will have a lower unit strength, but this may be compensated for by employing a thicker section and/or by employing a strengthening material, such as plywood or fabric. In the case of sheet stock, the thickness might be doubled without attaining a weight of sheet quite equal to that of the metal and this increase in thickness might greatly increase buckling strength, which is of great importance in many aircraft structures. In the case of fuselage, wing and control structures, plastic (resin) bonded plywood has been substituted for aluminum alloys, at least on an experimental scale, with an actual saving in weight and, it is claimed, with a marked reduction in fabrication cost and with a noteworthy gain in rapidity of manufacture.

It is not contended, of course, that plastic of the type in question (really wood is the chief material involved) can take the place of aluminum in all cases or types of structure, but reports indicate that it has done so in some cases and can be made to do so in many others. It is in this direction that a possible primary saving in aluminum, and to some extent in magnesium may be brought about. There are, of course, some problems remaining to be solved, but the chance of their solution appears bright.

Extruded Plastic Products

Another, though much less important saving probably can be made in substituting extruded plastic products for certain extruded or drawn aluminum or magnesium parts. All the thermoplastics can be extruded and the acetate-butyrate and the polystyrene types have been or shortly will be used for aircraft applications calling for aluminum before. This applies especially to tubing for electric wire conduits and might be made to apply to some other "shapes" in which stresses are moderate to nil. Certain of the vinyl plastics make extremely flexible and fire resistant insulation and are being extruded over wire in place of rubber or artificial rubber insulation. Although this is far from substituting plastic for metal, it may result in weight saving and might even make it possible to do away with a metal conduit in certain applications in which it has been thought necessary before.

Although most of the molded plastics are well below the cast aluminum and magnesium alloys in unit strength and still further below the wrought alloys based on the same metals, there are still cases in which a substitution can be made, even in aircraft applications, as for instrument panels, for example. In such cases, the extent of saving in light metals may not be very large, but it ought not to be insignificant. In these, as in all other cases, whether aircraft are involved or not, the change-over should not be attempted unless (1) a very similar substitution is known to have been made with success, on a production basis, or unless (2) a sufficient time can be allowed for thoroughly testing the substitute plastic in the particular application. Such factors as dimensional changes with aging, tendency to cold flow and/or to warp, resistance to weathering, ability to withstand extreme changes in temperature and humidity, among other considerations, certainly bar some types of plastics entirely and other types to some extent. Failure to recognize this may be just as serious as to overlook certain shortcomings of metals and their alloys.

Other Angles

There are, of course, many other angles of the whole situation (such, for example, as questions of availability of plastics in adequate quantities and of equipment for producing them and for fabricating them into the forms required) which must be given attention but which can only be mentioned here. Clearly, however, there are places in which plastics can have some effect upon metal shortages. Under existing circumstances, it is the job of the engineer, the production man, the chemist and even the metallurgist to do his share toward seeing that plastics are made to do their share in helping to ease metal shortages at least in those applications which appear promising. Everything points to the job being done with credit, for the type of men mentioned are hard to stump, once they understand what is wanted and set about doing it with characteristic energy and insight.

The Output of Steel Castings

By EDWIN F. CONE

Possibly an apology is in order for the presentation, so late in the year, of statistics of the steel foundry industry for 1940 and previous years. But an analysis of such data, we believe, is valuable as showing important trends. The lateness is due entirely to the difficulty in assembling all the facts which enter into the picture—this has required labor and patience, and was rendered successful by the cordial and helpful cooperation of the S. F. S. A. and others.

THERE IS NO STATISTICAL coordinating agency which furnishes data giving the production of the American steel foundry industry as a whole. And this industry, in its various departments and ramifications, is a very important one. There are not only the many foundries producing miscellaneous and special commercial steel castings, the main part of the industry, but there are also the makers of the high alloy or heat and corrosion-resisting castings, the high manganese or Hadfield steel products, as well as the ingot steel producers who make castings mostly for their own use.

No single organization assembles the production data of these various types of steel castings. The Steel Founders' Society of America collects the production figures of its members who constitute the large majority of the industry; the Alloy Casting Institute assembles the data of its members, the makers of high alloy products; the Manganese Steel Founders' Society at one time canvassed its members, the producers of high manganese (12 to 14% Mn) products but this organization has been disbanded; the American Iron and Steel Institute reports the steel ingot and the castings output of companies making ingots in the steel industry.

In most cases the data, thus assembled, are not published.

One other agency collects and publishes production data of the industry—the Bureau of Census of the U. S. Dept. of Commerce. While these are valuable, they include some of the companies outside those making miscellaneous and special alloy commercial castings. This in part explains the fact that their totals are considerably higher than those of the S. F. S. A.

Assembling the Data

It is the object of this article to briefly summarize this situation and assemble a table of the approximate production of the industry as a whole. The Table, here presented, covers the last four years; for earlier years, other articles[1] can be consulted.

The method used in preparing the Table is as follows:

The data, furnished the author by the Steel Founders' Society of America, are regarded as representing 95 per cent of the makers of miscellaneous and special commercial castings—these data are brought up to the 100 per cent level in the Table.

The output of steel castings by ingot producers is obtained by taking the difference between the total steel ingot and castings output and the ingot steel output as published by the American Iron and Steel Institute.

The Alloy Castings Institute has very cooperatively

Approximate Output of Steel Castings—Net Tons

	1937	1938	1939	1940
Miscellaneous and Special Commercial	955,440	310,050	529,710	718,500
Ingot Producers	280,620	155,850	261,275	332,800
High Alloy (Cr, Ni-Cr, etc.)	6,850	4,030	6,090	7,500
High Manganese (12 to 14 Mn)	50,000	28,000	30,000	45,000
Totals	1,292,910	497,930	727,075	1,103,800
Electric*	328,800	108,500	184,600	246,800
Per Cent of Total	25.4	21.8	25.3	22.4
Alloy†	295,700	109,500	168,500	232,100
Per Cent of Total	22.8	21.9	23.1	21.1

* Includes high alloy (stainless and heat resisting).

† Includes high manganese (Hadfield steel) and high alloy castings.

furnished its data of this branch of the industry.

To obtain the figures for high manganese castings, in the absence of the defunct Manganese Steel Founders' Society, it has been necessary to average totals estimated from various sources.

Electric and Alloy Steel

In the Table there are also figures for each year approximating the electric and alloy steel for steel castings. These data are arbitrarily figured, *advisedly,* on the basis of 33.7 per cent for electric steel and 25 per cent for alloy steel of the totals for miscellaneous and special commercial castings. To these rather arbitrary figures, in the absence of accurate returns, are added the high alloy castings output for the total electric steel, and the high manganese and the high alloy totals for the total alloy steel. The electric steel total is probably low since it does not include the high-manganese made in electric furnaces.

Detailed comment on the results as given in the Table is not necessary—they tell their own story. A feature is the rather unexpected fact that 1937 has been the best year of the four (and of the period 1934 to 1940) despite the expanding operations of the steel industry as a whole in 1940. The same remark applies to the electric and alloy steel output. In general, with this exception, the trends have followed those of the ingot production.

Reference to previous analyses[1] of this nature shows that output of the industry in the late 1920's exceeded anything since.

References

[1] "Production Data of the Steel Foundry Industry," *Metals and Alloys,* April 1937, page 111.

"Production Data of the Steel Foundry Industry for 1937," *Metals and Alloys,* July 1938, page 178.

"Ascendency of Alloy Steel Castings," *The Iron Age,* Aug. 24, 1933, page 11.

Pouring electric steel into sand molds from a tilting "teapot spout" ladle. (Courtesy: Pittsburgh Electric Furnace Corp.)

Transformation Structures of

In an article in METALS AND ALLOYS, *January, 1940, pages 6 to 13—"Hardenability of Molybdenum S.A.E. Steels"—R. M. Parke and A. J. Herzig offered supplementary data on austempering and described an improved dilatometer for studying the rate of transformation, particularly for steels containing molybdenum. It will be recalled that this article was intended to supplement some discussions on the Campbell Memorial Lecture by E. S. Davenport delivered in October 1939.*

In a forthcoming revision of its book on Molybdenum in Steel, the Climax Molybdenum Co., will publish further researches from its laboratory in Detroit, giving the results of expanded work in this field. We are glad to reproduce here the portion of this discussion which covers microstructure. Photomicrographs of certain plain carbon, carbon-molybdenum, Cr-Mo (4140) and Ni-Cr-Mo (4340) steels show the structure at various transformation temperatures. —*The Editors.*

THE MICROSTRUCTURE OF STEEL, its chemical composition and thermal history are interdependent. Complete knowledge of any two of these factors permits prediction of the third. In other words, if the thermal history and the chemical analysis of a commercial steel are known, reasonably accurate deductions regarding microstructure are possible. Again, given the composition and desired microstructure, the cooling rate is fixed. (The comparatively minor effects of grain size, segregation, non-metallic inclusions, etc., are not considered here.)

The discussion which follows has been inserted to clarify the complex relationships between the microstructure, the composition and the thermal history of plain carbon and alloy steel. Typical microstructures of 0.40 per cent C steels, both alloyed and unalloyed, are given. With the aid of these typical microstructures (which illustrate the text) and the S-curves it is believed that a better and more comprehensive understanding of steel microstructures may be obtained.

The ability to correlate cooling rate, microstructure and composition is largely a result of the study of isothermally transformed steels. These studies have revealed that the microstructure of a steel is determined by the temperature at which the transformation of austenite occurs. Where two steels have approximately the same carbon content, although different alloy content, there are usually marked similarities of structure *if the steels have transformed at the same temperature.* (Does not apply to highly alloyed compositions such as high speed, stainless, etc.) The principal effect of the several alloying elements on steel microstructures is to change the temperature at which the bulk of transformation takes place, by reason of the effect such alloys have on the rate of transformation at and above the nose of the S-curve. Once the critical cooling rate of the steel has been exceeded, the temperature of transformation below the nose is largely controlled by the carbon content. This has been shown in the preceding discussion.

Practical Applications

It has been found possible to use photomicrographs such as those here reproduced as a guide for working out the composition-microstructure-thermal history relationships in practical applications. Of course, the extent of their practicability is governed by the degree to which the microstructure under observation deviates from isothermally produced microstructures. Experience has demonstrated that, in many commercial sizes and treatments, transformation takes place in a sufficiently narrow range of temperature to permit comparison with isothermally produced microstructures. Despite an apparent substantial deviation in individual applications, an examination of *localized* areas of a commercially treated steel reveals structures which do not differ seriously from isothermal decomposition products. Useful predictions can, therefore, be made and enlightening postmortems may be held to determine the manner in which commercially treated parts have responded to heat treatment.

The steels whose microstructures are depicted herein were treated as ½ x ½ x 0.050 in. strip. These samples were quenched into a molten bath and held at temperature until transformation was virtually complete. The following general observations are pertinent:

1. The hardness of the structure generally increases as the transformation temperature of the steel decreases.
2. When transformed above 1000 deg. F. the structures of the several steels are predominantly lamellar pearlite and ferrite, each having resulted from the same mode of transformation.
3. As the transformation temperature is lowered, the pearlite colonies become smaller and less clearly resolved, the grains of ferrite disappear and the structure begins to take on a needle-like appearance. All steels transforming within this range show structural similarities, regardless of the presence of alloy addi-

Some Forty Carbon Steels

From the Research Laboratory, Climax Molybdenum Co. of Mich., Detroit

tions. This is especially true of the structures formed at 500 to 900 deg. F. range.

4. Where transformation takes place at about 400 deg. F. (not shown in Chart), the decomposition product (martensite) is strikingly similar for all steels. However, the time required for complete transformation varies from steel to steel.
5. If the steels transform at relatively high temperatures, and the time necessary to complete transformation is substantially different, the appearance of the structure formed is often noticeably different. For example, at 1200 deg. F., the plain carbon steel was virtually completely transformed after only 10 seconds, whereas the carbon-molybdenum steel needed 1000 seconds to complete the gamma-alpha change. During this comparatively long reaction period, substantial islands of ferrite have accumulated in the carbon-molybdenum steel. It is also interesting that the hardness of the two structures is markedly different.
6. Another noticeable difference in appearance exists between the plain carbon and the chromium-molybdenum-nickel steels which have transformed at 1150 deg. F. and 1250 deg. F. respectively. As compared with a time of 25,000 seconds for the chromium-molybdenum-nickel steel to transform at both these temperatures, the plain carbon steel needed only 10 seconds (at 1150 deg. F.) and 100 seconds (at 1250 deg. F.) for completion of transformation. The spheroidization which took place before the chromium-molybdenum-nickel steel had completely transformed seems to be associated with the long time required for the gamma-alpha iron reaction to proceed to completion. (There is also the possibility that the presence of some undissolved carbides in the steel at the austenizing temperature may have influenced the rate of spheroidization and, consequently, the appearance of the microstructure.)

Nevertheless, it may be said that the product of decomposition of austenite is determined by the temperature at which transformation takes places.

It must be remembered that microstructures obtained by quenching very small specimens may not be easily obtained in practical heat treatment. The S-curve of a plain carbon steel shows temperature ranges of extremely rapid transformation rate, indicating that some of the structures shown (particularly at temperatures below about 1150 deg. F. are obtainable only in small sections, and even then only with closely controlled heating and cooling cycles.

Effect of Alloying Elements

As pointed out earlier, alloying elements may greatly retard the rate of transformation. For example, when molybdenum is added, this retarding of the reaction rate often makes it possible to obtain structures characteristic of transformation below 1150 deg. F., while using ordinary heat-treating practice on commercial size specimens. The addition of chromium, nickel or other alloying elements to the molybdenum steel still further retards the rate of transformation of austenite, thereby increasing the range of structures obtainable in practical section sizes using commercial heat-treating methods.

The inter-relationship of the composition, microstructure and thermal history of steel has been shown —as has the fact that this information can be conveniently summarized in the form of S-curves and microstructure charts.

The following examples of the practical usefulness of these data may be mentioned. If the transformation characteristics of a steel are known, a study of its S-curve will show the *slowest* cooling rate permissible for full hardening. Even if it is not desired to harden a piece fully (even when water quenching), the S-curve and typical microstructure data are nevertheless useful as guides with the slower cooling rates. Actually, S-curves and typical microstructures have been extensively applied where only limited hardening or controlled softening of the steel is desired.

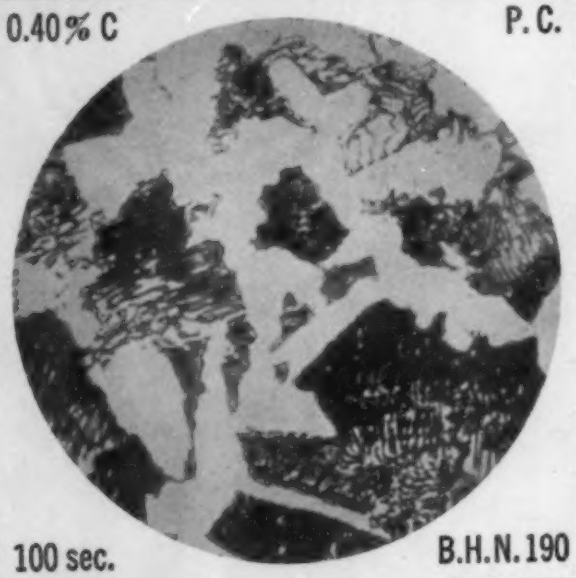
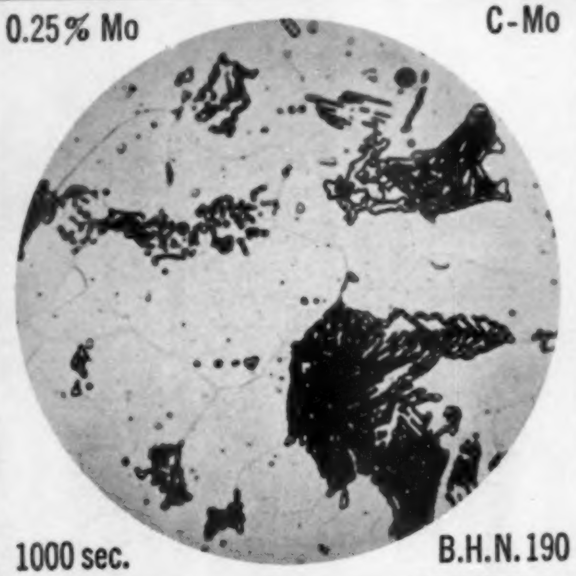
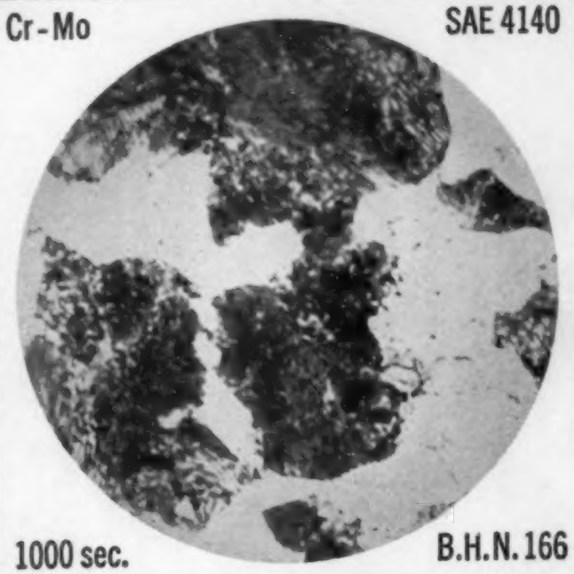
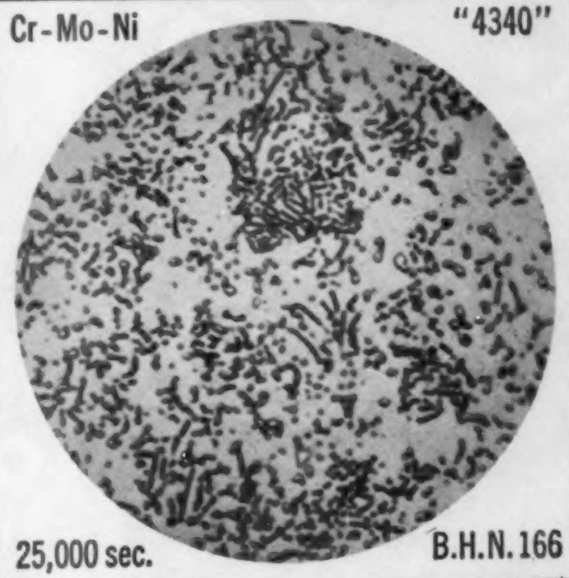
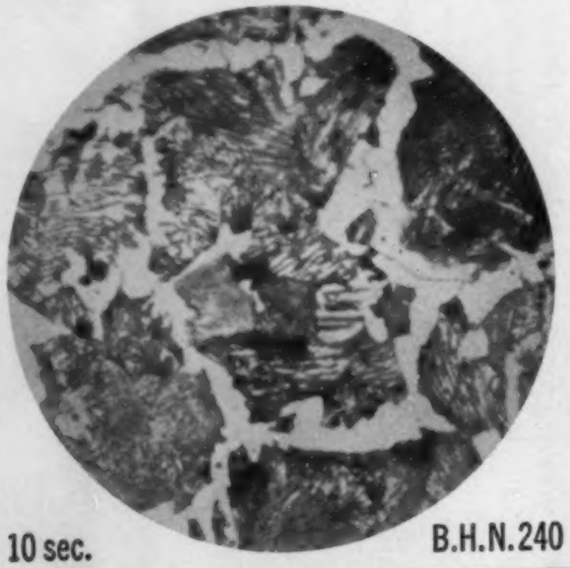
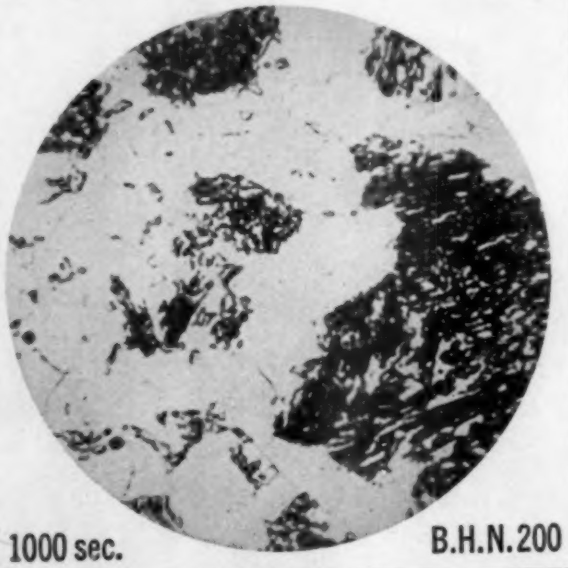
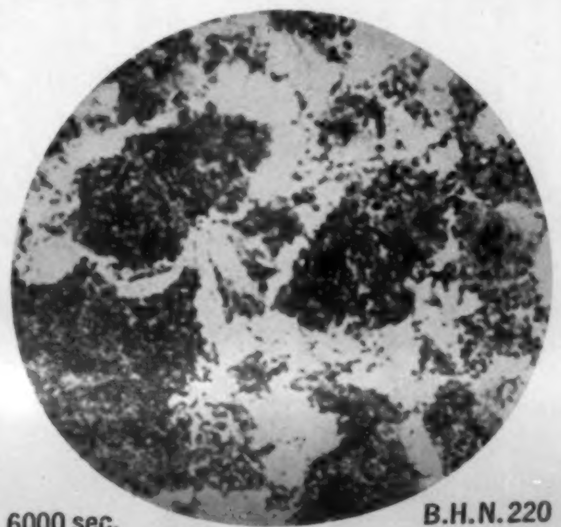
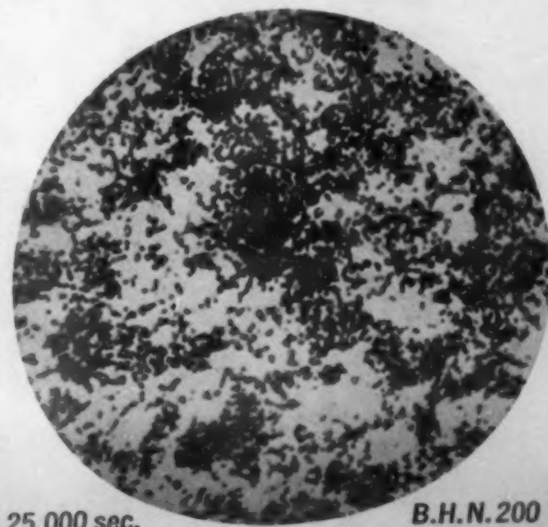
Practical Heat Treatment Cycle Predictable

With the aid of an S-curve and a microstructure chart, the metallurgist can now predict a practical heat treatment cycle for a steel which is to be treated in a given section. With this precise information regarding the transformation characteristics of the steel, technically qualified persons may often be able to suggest specific heat-treating cycles that will reduce the furnace time necessary to produce a desired structure. In addition to this, an examination of the microstructure obtained in the actual commercial heat treatment will indicate the errors, if any, in the practical application of these data.

Despite the fact that S-curves and microstructure data are not as yet precise metallurgical tools and must, therefore, be used with caution by the inexperienced, they deal with heat-treated steel in a truly scientific manner. No assumptions regarding equilibrium conditions (which are rarely encountered in practical metallurgy) are necessary. These new metallurgical tools, dealing with cooling conditions as they actually exist in steel, even if only locally, are of definite practical value to the metallurgist in predetermining the response of steel to quenching, normalizing or annealing.

(See photomicrographs on next four pages)

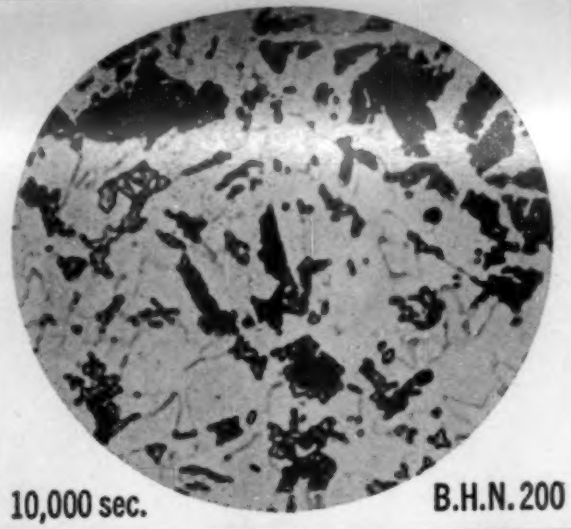
Microstructure of 0.40% Carbon and Alloy Steels Wholly Transformed at Temperatures Shown - 1000 Diameters

Transf. Temp. °F.	0.40% C — P.C.	0.25% Mo — C-Mo	Cr-Mo — SAE 4140	Cr-Mo-Ni — "4340"
1250	 100 sec. B.H.N.190	 1000 sec. B.H.N.190	 1000 sec. B.H.N.166	 25,000 sec. B.H.N.166
1200	 10 sec. B.H.N.240	 1000 sec. B.H.N.200		
1150	 10 sec. B.H.N.240	 10,000 sec. B.H.N.200	 6000 sec. B.H.N.220	 25,000 sec. B.H.N.200

10 sec. B.H.N. 240 | 10,000 sec. B.H.N. 200 | 6000 sec. B.H.N. 220 | 25,000 sec. B.H.N. 200

1100

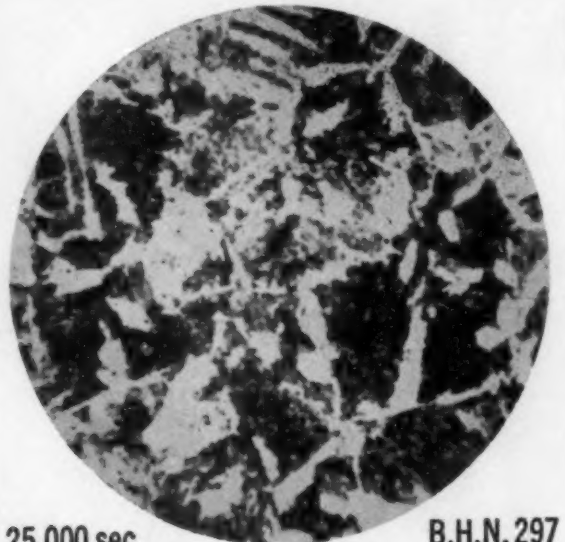

5 sec. B.H.N. 260


10,000 sec. B.H.N. 200

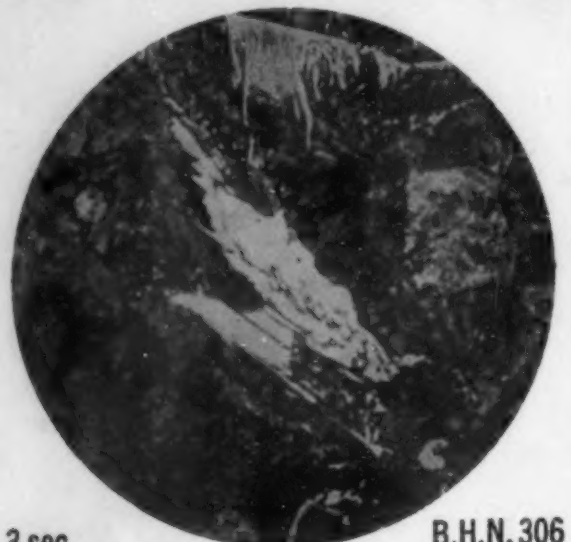
1050

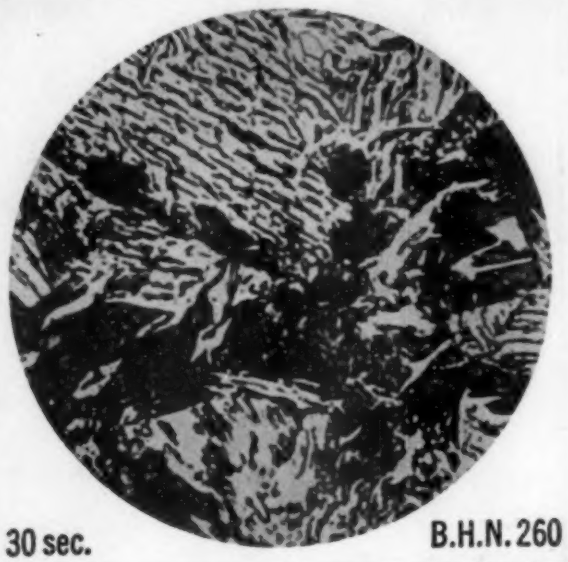

10 sec. B.H.N. 269


1000 sec. B.H.N. 240

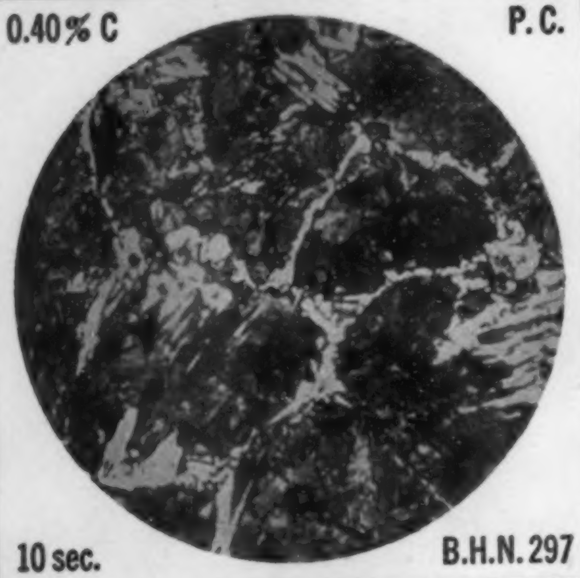
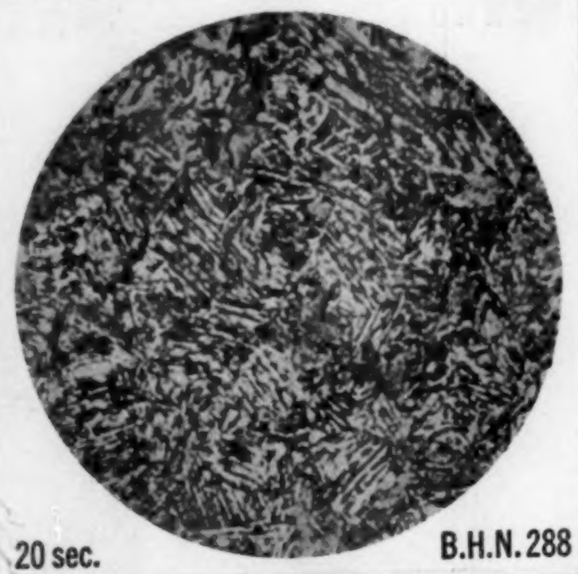
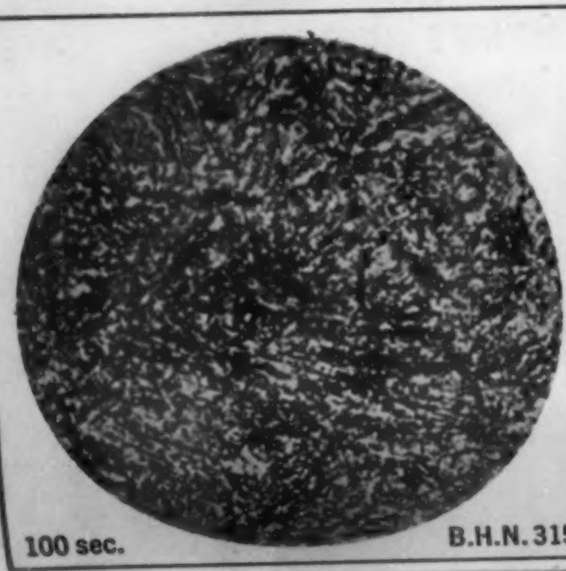
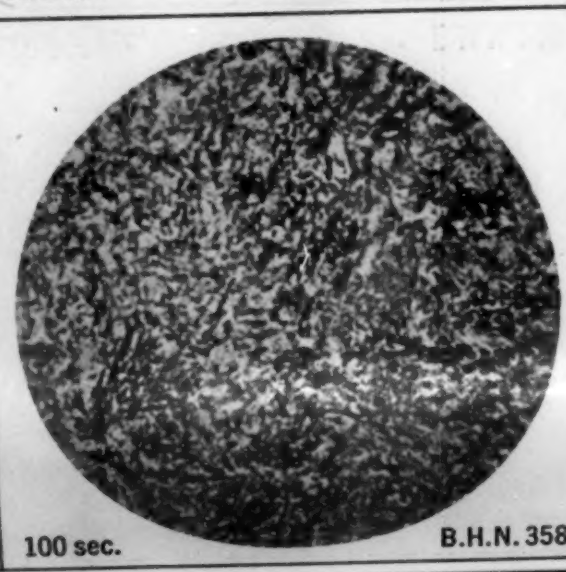
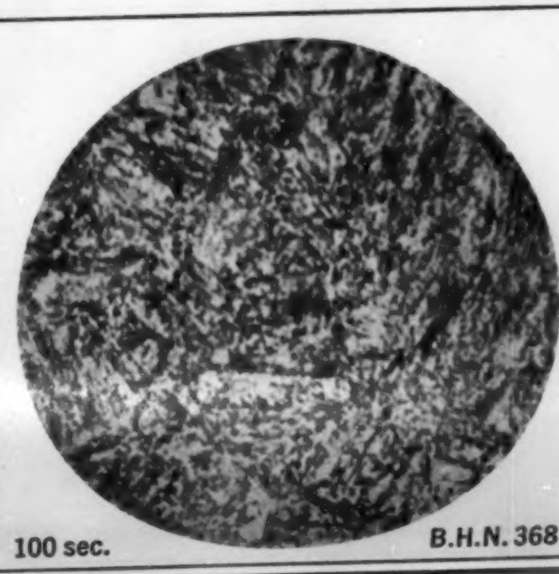
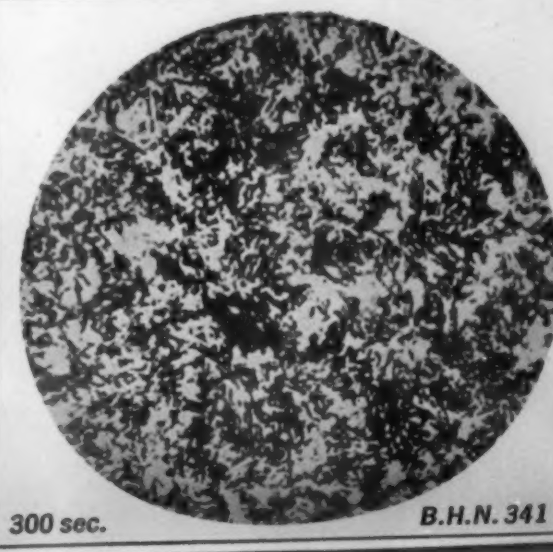

25,000 sec. B.H.N. 297

1000


3 sec. B.H.N. 306

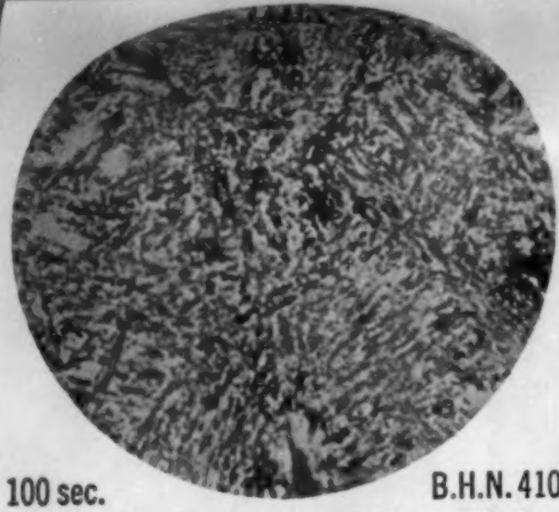

30 sec. B.H.N. 260

Microstructure of 0.40% Carbon and Alloy Steels Wholly Transformed at Temperatures Shown - 1000 Diameters

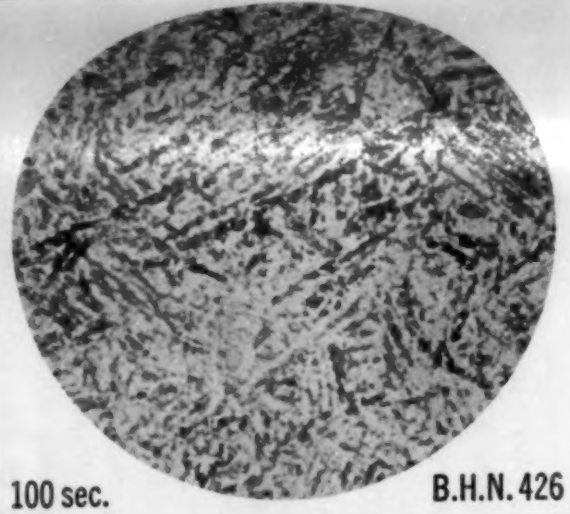
Transf. Temp. °F.	0.40% C — P.C.	0.25% Mo — C-Mo	Cr-Mo — SAE 4140	Cr-Mo-Ni — "4340"
950	 10 sec. B.H.N. 297	 30 sec. B.H.N. 260	 25,000 sec. B.H.N. 288	
900	 20 sec. B.H.N. 288	 20 sec. B.H.N. 288		
800	 100 sec. B.H.N. 315	 100 sec. B.H.N. 358	 100 sec. B.H.N. 368	 300 sec. B.H.N. 341

100 sec. B.H.N. 315 | 100 sec. B.H.N. 358 | 100 sec. B.H.N. 368 | 300 sec. B.H.N. 341

700



100 sec. B.H.N. 410



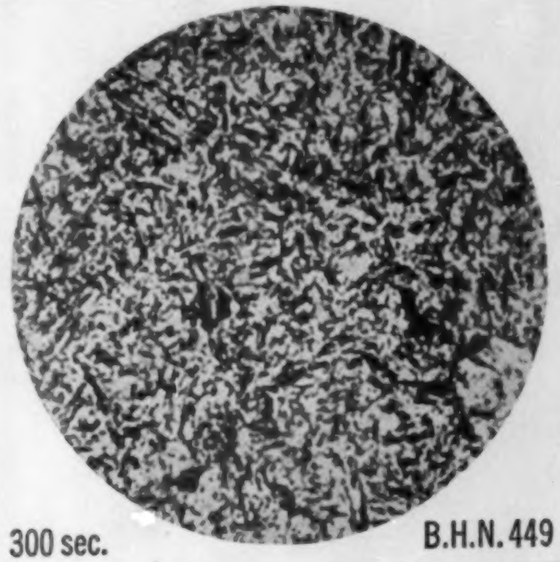
100 sec. B.H.N. 426

600

300 sec. B.H.N. 495

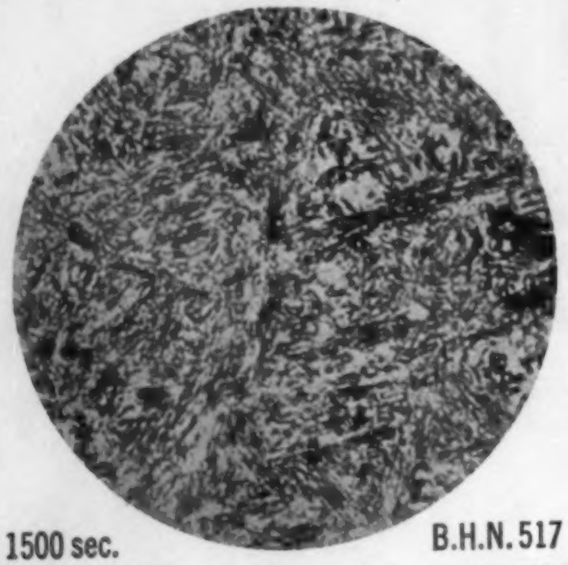
300 sec. B.H.N. 488

100 sec. B.H.N. 495

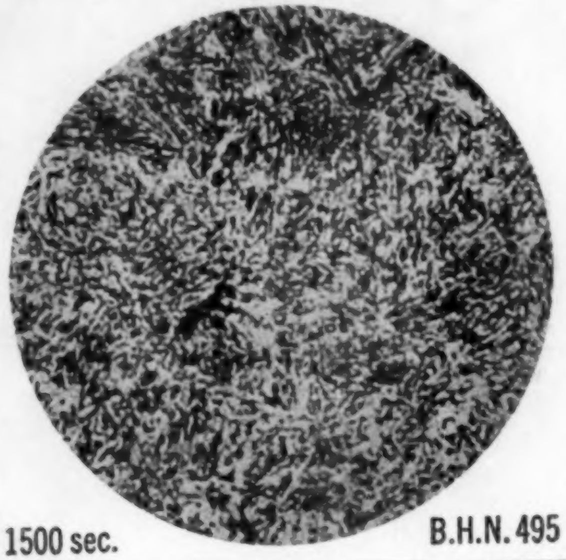


300 sec. B.H.N. 449

500



1500 sec. B.H.N. 517



1500 sec. B.H.N. 495

Editorials *(Continued from page 293)*

users. For flexibility, some such provision may be wise, but the stock should not be dissipated in that fashion. All the necessary metals should be stock-piled in at least a three-years' supply at a rate of consumption considerably greater than our maximum annual need for them in the present emergency.

Ores don't deteriorate in storage, nor, with proper precautions against rusting or corrosion in storage, do metals. Low-grade ores in the ground will certainly show higher recovery by the technology of 15 years from now, than they can today.

If the Army and Navy, rather than pacifist politicians, had had their way, we could now have both guns and butter, could avoid unemployment caused by lack of raw materials and would not have all the priority headaches.

Now is the time to agitate for bigger and better stock-piles!—H.W.G.

Cupolas Duplexed with Open-Hearths

The tremendous demand for steel, and the insistence on increased output, has caused the open-hearth people to investigate with interest any proposed method which will increase open-hearth furnace capacity. This is especially true if the proposed method has a chance of accomplishing this purpose without the necessity of building additional open-hearth furnaces.

Large investments in labor and material are required to construct new open-hearths, but the really serious factor is the time involved, while our defense program is calling for speed and more speed.

Many open-hearth plants, some of them with capacities exceeding 1,000 tons of ingots per day, do not operate blast furnaces, and of necessity must depend on an all cold charge. In localities where scrap is cheaper than pig iron steel is being made with an all scrap charge and a percentage of cast iron and coke is being used to furnish the necessary carbon.

The hot-blast cupola, using an all scrap charge, produces metal which is an acceptable substitute for molten pig iron. Such cupolas can be built in sizes to produce up to 30 tons of iron per hour. Sulphur can be reduced to any desired percentage by treatment with caustic soda or soda-ash in the ladle. The carbon content is about 2.75 to 3.00 per cent regardless of the scrap charged. If a large percentage of steel scrap is used, carbon is absorbed from the coke in the cupola.

As compared to any open-hearth furnace using an all cold charge, it is reported that a furnace charging about 40 per cent of hot cupola metal, will show an increased output of 30 to 40 per cent.

Several installations have been recently purchased and others are under consideration. Cupolas can be built in much less time than open-hearth furnaces, and the cost of a cupola installation is a fraction of the cost to produce the same increase in tonnage by building additional open hearths.—E. F. C.

Another stunt deserves to be mentioned in this connection.

Open-hearth operation can be speeded if the hot metal does not run too high in silicon. Running the blast furnace with a primary view to getting hot, low sulphur metal, letting the silicon run where it will, then reducing the silicon content to say 0.50-0.80 per cent by addition of ore and lime in a mixer-type intermediate container and allowing the exothermic reaction to take place there, provides hot metal of much lower silicon content and slightly lower carbon. It takes less lime, less slag volume, and less time for the open-hearth heat, and such a charge can get along with less scrap than a conventional one.—
H. W. G.

Substitutes in the Automobile—Now and After

We hear a great deal these days about substitutes, particularly metals, in industry in general, but especially in the automobile. Substitutes, or at least a reduction in quantity, are now the rule in automobiles—less zinc, aluminum, magnesium, tin, copper, etc., or total elimination of some. Malleable iron, cast iron and steel, are being used as substitutes for non-ferrous metals. Carburetors and fuel pumps are or will be made of cast iron instead of zinc. Plastics are also a factor. The tendency is towards a drastic cutting off of the critical metals in cars.

But substitute methods of manufacturing automobiles are figuring, or will also figure, prominently in the effort to conserve these metals, according to the views of leading automotive engineers now studying the problems which confront the industry. It is evident that the use of substitute materials automatically gives rise to the necessity for substitute manufacturing methods. For example, note the great change in machining involved in making steel and cast iron pistons which are replacing the aluminum ones. And there are other similar cases.

What then of the future? An answer is more or less guess work. Some of the technical leaders in the industry are reported to believe that not many of the changes will be discarded when the emergency is over. There are those, on the other hand, who firmly feel that the "old order" will return. In any event much will depend on the success of the "new order." If the use of zinc, aluminum, and other metals was adopted originally because of their superiority over other materials, is it not to be expected that a return to some or all of these materials will take place?

Where there is little difference in the cost of material A + method A over material B + method B, whichever one is in use will tend to remain in use so that the equipment for the method can be utilized. Unless the engineering advantages of one scarce material in the finished product overbalance the cost of sluffing methods and equipment, the "substitute" will stick.

Hence *some* of the substitute materials will stay put; in other cases use will revert to the previous materials.—E. F. C. and H. W. G.

Jobbing Heat-Treating Plants

We had the good fortune recently to be shown through the heat-treating establishment of a leading company doing jobbing heat-treating work. In this one organization there is an array of heat-treating equipment which is probably the largest in this country and which is decidedly impressive. Among the some 135 furnaces there is practically every type of furnace and every process for heat treating. In these days all of it is crowded with work and the organization is fully occupied in solving Defense and industrial problems in this field.

This experience impressed us with the importance of organizations of this kind located throughout the country. How many of these there are, it is difficult to say, but there are many. There exists the Metal Treating Institute, Inc., which has 30 member companies (July 1), located in or near industrial centers in many parts of the country. And besides these there are doubtless many others, large and small. An incomplete survey has revealed the fact that there are over 600 heat-treating furnaces and equipment operated by 14 members of the Institute.

The importance of the jobbing heat-treating laboratory, or establishment, to the Defense Program in particular and to industry in general in normal times cannot be exaggerated—it plays a highly vital role. In doing actual work and also in an advisory capacity these organizations are definitely essential. The metal working and other plants which do not have their own heat-treating departments must depend on these for guidance and for completion of their own orders. We have progressed decidedly in a quarter century —then the science or art of heat-treating was in its infancy.—E. F. C.

---

letters TO THE EDITOR

Our Real Steel Capacity

To the Editor: I note in the August issue of METALS AND ALLOYS your editorial—"Our Real Steel Capacity," and believe the following sentence may be misleading to the average reader; "This (increase in tonnage) has come about by speeding up blast furnace, open-hearth and electric furnace practice and by necessary gradual enlargements of capacity."

This, in my opinion, leaves the average reader under the impression that the industry is shortening time of heats with a natural inference that quality may be impaired. The increase in capacity has been mainly due to enlarging furnaces and the installation of additional open-hearth and electric furnaces.

ONE OF YOUR READERS

It was not the intention to convey in the editorial an impression that the industry is shortening the time of heats with a possible sacrifice in quality. It is generally acknowledged and known that the steel industry is doing all it can to supply the tremendous demand and that its cooperation with the Defense Program is 100 per cent. Certain improvements in metallurgical practice have been put into operation which have increased output and it was to this and other devices which we referred.

These improvements in practice and equipment, combined with gradually expanding capacity, are responsible to a large degree for the excellent showing of the American steel industry.—E.F.C.

Problems in Transient Heat Flow

To the Editor: Because there are direct analogies between specific heat and electrical capacity, thermal conductivity and electrical conductivity, it is possible to solve numerically problems of transient heat flow by utilizing the electric analogy even in cases where mathematical analysis is inapplicable, either because of the irregularity of the shape or because of the change of thermal properties of the body with temperature.

Experimental difficulties exist in determining the actual temperature gradient, *i.e.* the uniformity of temperature within the piece, in heating and still greater in cooling (quenching).

An assembly of electrical condensers (capacitors) and resistors may be set up to produce an electrical model representing the piece whose heat flow characteristics are to be studied. Control of, and measurement of voltage, corresponding to temperature; and measurement of current, corresponding to heat flow made with such an assembly, can be made to picture the thermal behavior of the object subjected to heat flow (*e.g.* to be heat treated). The electrical values thus obtained can be, by calculation, transformed to give the desired heat values in deg. F. and B.t.u. per hr.

The duration of an experiment on the electrical model need not be the same as the duration of the heat process. By appropriate choice of the electrical units, a "Time Ratio" can be applied: Thus data applicable to slow heating processes may be secured in minutes, and those applicable to almost instantaneous quenching problems may

be secured at a conveniently slow rate, allowing easy reading of the instruments.

A 15 section set up with necessary recording instruments is installed in the Mechanical Engineering Dept. of Columbia University, New York.

The method is described in a paper by V. Paschkis and H. D. Baker, presented at the annual meeting of the Applied Mech. Div. of the A. S. M. E. in Philadelphia, on June 20-21, 1941, and will be printed in the *Transactions* of the A. S. M. E. An account, containing photos of the equipment and avoiding mathematical and electrical details has been published by P. W. Swain in *Power*, July, 1941.

VICTOR PASCHKIS

Department of Mechanical Engineering,
Columbia University

Forgings vs. Welded Assemblies

To the Editor: The article "Forgings Versus Welded Assemblies," on page 734 of your June issue, represents an excellent example of a case where an aluminum alloy forging replaced an arc welded chromium-molybdenum steel fulcrum. This changeover was amply justified by the tremendous increase in production which sufficed to absorb the cost of the necessary dies so that the unit cost was actually decreased. Another controlling factor was that it was found impossible to produce enough arc welded steel fulcrums without an undue percentage of defective parts and rejects.

Unfortunately, it appears that some readers have interpreted the article as implying that all welding is defective and inferior to other methods generally. I feel certain that it was not the intention of the authors to give this impression. Welding as well as forging has many outstanding applications for which it is preferred. The aircraft industry now uses and probably will continue to use many welded parts in their airplanes for which welding has demonstrated itself to be the best method of manufacture.

I would appreciate your publishing this letter as I feel that it might be of some aid in dispelling the erroneous idea which some readers seem to have acquired as a result of being misled by the rather unduly broad title of the above mentioned article.

E. V. DAVID

Assistant Manager, Applied Engineering Dept.,
Air Reduction Sales Co.,
New York

A Few Chuckles

Baldness and High Temperatures?

To the Editor: METALS AND ALLOYS, May, 1941, p. 570 (but not so marked):—"as closely spaced as the teeth in a woman's comb". Some of the gentlemen in the following illustrations have no use for a comb, closely spaced or otherwise. The combination reminds me of a point I have heard debated, "does work on jobs employing high temperatures contribute to baldness"? Some of the younger men in the picture seem to be on their way there. Others have arrived—and probably are darn good casters. Tell me the truth now, no spoofing.

Joseph Dixon Crucible Co.,
Jersey City, N. J.

S. B. SEELEY
Ass't. Director,
Research & Tech. Div.

Modern Improvements—a Hot Weather Note

In a Columbus newspaper we note that a local clinical laboratory examines specimens with the most modern equipment, including high-power microscopes and air-conditioning.

And in July *Refrigerating Engineering* we find that the Outagamie County Jail, Wisconsin, is installing air-conditioning for the delousing room and the infirmary.—H.W.G.

An Exception to A Chuckle

To The Editor: On Page 450 of the April, 1941 issue of METALS AND ALLOYS you have a short item headed: "Live and Learn!—A Chuckle".

In this case I am afraid the chuckle is on you. In coin detecting devices magnets are used to deflect the trajectory of brass and copper slugs as well as to stop the passage of magnetic slugs. You will remember that when a conductor moves through a magnetic field it generates eddy currents within itself. These eddy currents in turn have an associated magnetic field which reacts with the static magnetic field to deflect the path of the slug. If you don't believe it, try it some time. I did.

Associated Electric
Laboratories, Inc.,
Chicago.

C. F. FFOLLIOTT

Three Definitions

We found on our desk recently a small booklet or pamphlet entitled—

"Complete and Classified Directory of Firms giving a better, Prompter Repair Service than we do."

The pages of the pamphlet were all blank!

But in the inside of the front cover were these definitions of an "Engineer," a "Salesman," and a "Manager" which struck a responsive chord in us and we pass them on for the benefit of any one interested—E.F.C.

AN ENGINEER is a man who knows a great deal about very little and who goes along knowing more and more about less and less until finally he knows practically everything about nothing.

A SALESMAN is a man who knows very little about a great deal and keeps knowing less and less about more and more until he knows practically nothing about everything.

A MANAGER starts out knowing practically everything about everything, but ends up knowing nothing about anything, due to his association with engineers and salesmen.

—UNKNOWN

METALLURGICAL ENGINEERING news

Equipment
Finishes
Materials
Methods
Processes
Products

Alloys
Applications
Designs
People
Plants
Societies

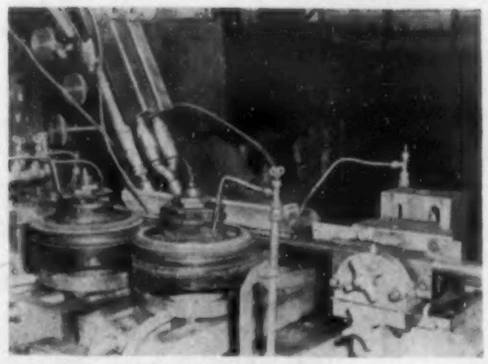
New Oxy-Acetylene Tube-Welding Machine

A new oxy-acetylene tube welding machine, developed by *The Yoder Co.,* Cleveland, in collaboration with *Linde Air Products Co.,* New York City, is employed for the continuous welding of tubing from low-carbon, stainless and other alloy steel skelp at exceptionally high production speeds. With this machine, it is claimed, high-quality tubing can be successfully produced from unpickled, hot-rolled stock for which there is considerable demand in the manufacture of low-cost items.

The forming-mill section of this machine is similar in construction to previously designed tube-welding machines. The flat skelp is fed in from a coil through a series of forming stands powered through a worm gear drive mechanism.

The welding table section of the machine consists of a new type multiple-flame Oxweld duplex welding head which, according to the designers, requires 25-30% less acetylene and 5-10% less oxygen per ft. of weld than welding heads previously used. Separate oxyacetylene supply lines are provided for the welding and for the preheat flames.

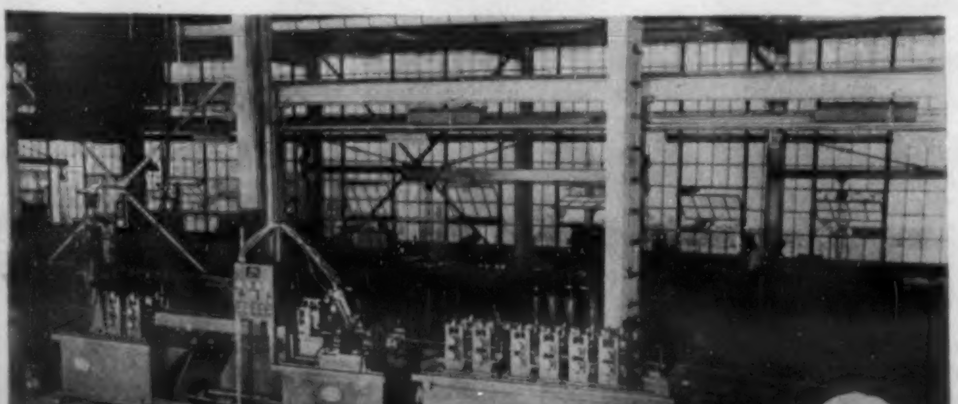
After it is welded, the tubing passes through a water quench trough and then through a set of rollers which straighten



Closeup of Welding

the tubing before it is cut into the desired lengths by means of an automatically operated shear.

General View of Operation



Finished Tubing After Test

The accompanying photograph shows a piece of the finished tubing after being subjected to crushing at one end and diameter expansion at the other without failure.

● *The Allegheny Ludlum Steel Corp.,* Pittsburgh, have available for use of interested groups a 16 mm., 800 ft. sound film entitled, "There's a Job to be Done," dealing with stainless and special steels and their place in National Defense. No charge is made for use of the film, but the user must have his own sound projector equipment.

(MORE NEWS ON PAGE 332)

WHEN YOU WANT LONGER-LIVED REFRACTORY PRODUCTS

FIRING LINE NEWS

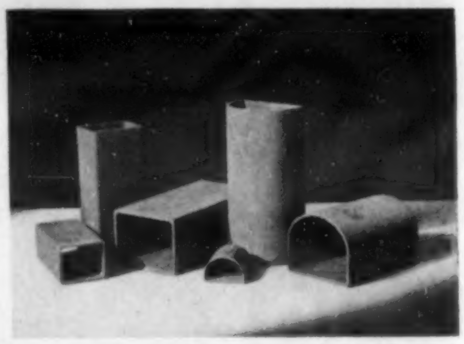
Versatility in Crucibles and Linings, to Fit Many Metals

— *For copper, copper alloys, manganese and stainless steel,* electrically fused magnesia crucibles or cements for lining larger crucibles. Basic in nature, fused magnesia is chemically inactive to both ferrous and non-ferrous metals.

— *For slag conditions* — CRYSTOLON (silicon carbide) crucibles and cements for lining larger crucibles in melting non-ferrous and non-lead-bearing metals, offer a highly refractory, impermeable surface resistant to the action of molten oxides. Lining replacement or patching can be readily accomplished with CRYSTOLON cements.

— *For oxidizing and other chemical conditions* ALUNDUM (Al_2O_3) crucibles and cements have an extraordinary degree of chemical inertness. Electrical resistance at high temperatures is also great. Very satisfactory for melting pure metals, especially those with high melting points.

WRITE FOR literature which gives full details



Shock-Proof CRYSTOLON Muffles for Heat-Treating Steel

In furnaces fired by oil, gas or electricity for heat-treating steel, CRYSTOLON (silicon carbide) muffles, of a mix matched exactly to your needs, combine in the highest degree, efficiency of heat transfer, great refractoriness, resistance to thermal shock from rapid temperature changes, and strength permitting unusual thinness of construction.

NORTON RESEARCH

Ingredient Number One in Longer Lived Refractory Products —

Refractory Shapes and Cements of CRYSTOLON (silicon carbide), ALUNDUM (fused alumina), and Fused Magnesia Grains

NORTON COMPANY, WORCESTER, MASS.

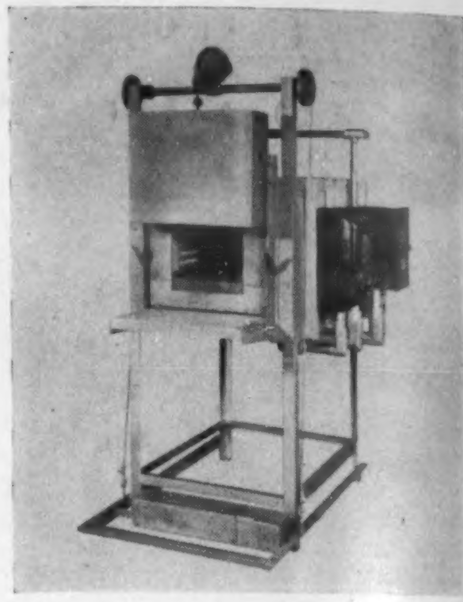
Electric Box and Muffle Furnaces

H. O. Swoboda, Inc., 206 Thirteenth St., New Brighton, Pa., announces production of a new line of "Falcon" electric box type and muffle type furnaces. These furnaces have been found to be particularly well adapted to a wide range of both general and specific applications for use in either factory or laboratory.

These furnaces are being used for testing of metal samples, melting of glass samples, burning of refractories, oxidation determinations, testing of vitreous enamels, heating of high speed and similar steels in tool rooms, for hardening and tempering, and many other widely varying applications.

The furnaces are arranged for either floor or bench mounting and are equipped with heavy alloy heating elements to assure efficient, long-life operation at temperatures up to 2300 deg. F. Heating elements are supported in high grade refractories arranged in top, bottom, side and rear walls of the furnace. Furnace chamber is completely surrounded by durable block type insulation.

The model illustrated has a chamber 9 in. high, 12 in. wide and 36 in. deep, with a 16 kw. capacity suitable for 2,000 deg. F. maximum operating temperature. Automatic temperature controls are mounted on the side of the furnace, completely wired for connecting to power supply. The fur-



nace is equipped with a foot-treadle operated door mechanism.

Air-Operated Tube Bender

The Pines Engineering Co., 123 Main St., Batavia, Ill., has developed an air-operated tube bender, claimed capable of producing an average of 250 bends per hr. on 1 in. 16-gage tube using a mandrel. The mandrel, which assures smooth bends, is available with either a mechanical or air-operated device for pulling it out of the bent tube in case it sticks.

Dies are actuated by the piston rod of an air cylinder. The air cylinder is controlled by an arrangement that makes possible very short air lines and reduces to a minimum the amount of air required for operation.

The bender has an arc-welded plate steel frame on which the dies and mandrel are mounted and the operating mechanism inside, readily accessible through a removable plate. The frame is designed with a small, but stable, pedestal, the overhanging top portion providing for the bending of intricate shapes that can be swung under the frame if necessary.

● To overcome the danger of fires and explosions caused by charges of static electricity accumulations on non-conductive surfaces, particularly in plants where the air is laden with dust, lint and other inflammable materials, copper or other metallic powders have been mixed with flooring cement to render the flooring conductive and to inhibit the building-up of such electrical charges, reports *Charles Hardy, Inc.,* New York.

Have you seen—and used—the new "index" form of MANUFACTURERS' LITERATURE, on pages 280-283?

Grinders

For tool and light snagging grinding, *Hammond Machinery Builders, Inc.*, Kalamazoo, Mich. have just introduced 3 new grinders. The design of the new machines features oversize construction for all moving parts such as spindles and bearings. The base of the machine is heavy cast iron with straight vertical lines unbroken by

protruding parts that might hamper grinding operations.

Streamlined into the base, at the top, is a heavy-duty motor-on-spindle for 10 in., 12 in. or 14 in. wheels. The motor can be 1, 2 or 3 hp., 220 or 440 v., 3-phase, 60 cycle a.c. All motors have a spindle speed of 1750 r.p.m.

● Plastic shoe string tips will release about 500,000 lbs. of metals, principally tin, to vital industries in 1941 alone, it was estimated by the Plastics Dept. of the *Du Pont Co.* One lb. of plastic replaces more than 3 lbs. of metal. Plastic tips, manufacturers say, are stronger, more compact and will outlast metal tips.

Arc Welder Control Box

A new dual continuous control for arc welding machines has been announced by the *Lincoln Electric Co.*, Cleveland, Ohio.

The new box, designated "Type G," is designed to prevent accidental contact with live parts, increase accessibility, permit wiring with flexible or rigid conduit, or rubber-covered multiple-conductor cable, and eliminate danger from loosening of the lifting hook. There are separate compartments for all a.c. circuits, and all d.c. terminals.

The central box is permanently grounded to the motor and generator frames through the mounting bolts. This feature makes it possible to ground both the control box and the machine by grounding the conduit, which leads to the box.

The snap catches on the compartment doors and lift hooks are of improved design for safety and convenience.

Springs With "No Temperature Error"

A new spring now available commercially utilizes the property of a 36% nickel steel to become stiffer as its temperature increases. These springs, manufactured by *All Weather Springs Co.*, New York, are combined with under-correcting springs; that is, springs having an opposite tendency or with other elastic elements such as bellow, diaphragms, etc., to produce instruments, the accuracy of which is virtually unaffected by temperature changes.

While the ordinary steel or alloy spring becomes approximately 2% more resilient for every increase of 100 deg. F. in temperature, it is claimed that these new self-compensating springs can be held constant within these limits to 0.02%.

These springs are now being used in spring scales, aeronautical instruments and other spring actuated instruments that must be used in localities where they are exposed to a wide variation in temperature.

● *Charles Hardy, Inc.* has been appointed by the Electro Metallurgical Sales Corp. as their sales agents for calcium metal.

Carbide Tools and Interchangeable Holders

Increased production between tool regrinds is made possible by the adoption of tungsten carbide tools and interchangeable holders, reports *Carboloy Co.,* Detroit.

The Consolidated Brass Co., Detroit, in the manufacture of cast brass pipe fittings, water gages, oil and grease cups, and other products, has increased production considerably through the adoption of these methods.

As many as 5,000 pieces are now produced where formerly only 200 pieces could be run before tool regrinding was necessary.

A rather unusual use for carbide tools has also been developed in connection with drilling operations. For such purposes, low cost carbide drills are used. The drills are built into the holders along with up to 6 standard tool bits and are used for drilling cored holes at the same time the exterior sections of certain fittings are turned or faced.

The holders are mounted in standard turret lathes and, in a sequence of simple cuts, are able to finish all the desired surfaces, ready for threading, when required. Formerly, the cored holes were bored with flat bits mounted in short pieces of round bar stock with shanks to fit into the turret head, a separate preliminary operation prior to further finishing of the exterior surfaces.

A feature of the holders is that once the bits have been properly formed from the standard tools and set in the correct position in the holders, they need only be mounted in the lathe turret. All operations are performed by the tools mounted in the holders, no cross-carriage tools being required for finishing the external surface, even though in some cases the length of cut on the external surface is several inches.

Some of the fittings are quite complicated in form with internal valve seats, chamfers, etc.

Mechanized Electric Salt Bath Furnaces

Completely conveyorized electric salt bath furnaces are now being made and installed in key defense industries, according to the *Ajax Electric Co.,* Philadelphia.

These mechanized electric salt bath furnaces are made for all heat treating operations from 300 to 2400 deg. F., including simultaneous brazing, carburizing, tempering, hardening molybdenum type high-speed steel tools, annealing, brazing and heating for forging.

Guided by an overhead conveyor screw, steel parts submerged in the bath travel through the furnace at a controllable speed for the duration of their heat treating period, during which high temperatures are held virtually constant to within a few degrees.

● A lightweight aircraft welding torch, weighing only 7 oz. and well adapted to precision work, is being manufactured by *National Cylinder Gas Co.,* Chicago, Ill. The torch is compact to get around jigs and fixtures and has front-end valve wheels for one-hand flame adjustment.

Processing Machine Gun Parts

A new type of equipment for tumbling or cutting down machine gun parts has been developed by *Hanson-Van Winkle-Munning Co.,* Matawan, N. J. The burrs on the machine gun parts were previously removed by filing by hand.

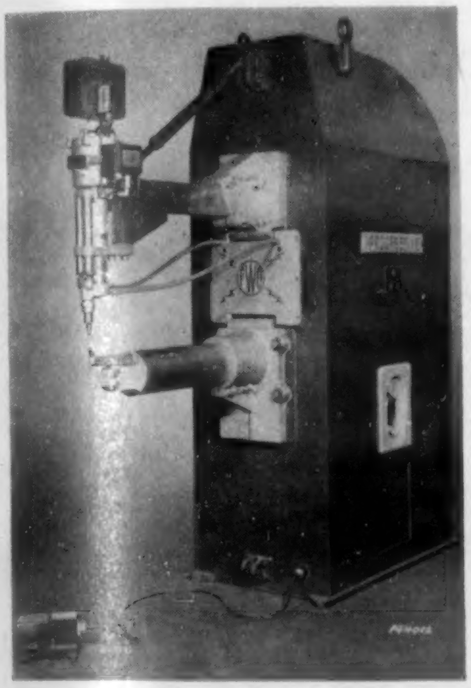
This machine, it is claimed, gives a better finished product than does filing by hand.

Deep Throat Resistance Welder

To facilitate resistance spot welding inside of deep assemblies, such as tanks of various types, *Progressive Welder Co.*, 3100 E. Outer Dr., Detroit, has introduced a variation of its pedestal welder.

The deep throat welder, shown in the accompanying illustration, has its lower arm built of heavy tubing and fitted with a replaceable adaptor for the lower electrode. The construction makes unnecessary the supporting of the lower arm by means of the usual braces, due to its inherent rigidity. Elimination of the usual braces, in turn, makes possible sliding deep assemblies over the arm to full throat depth.

The upper arm, carrying the upper electrode and gun assembly, is braced in the conventional manner. Both upper and lower arms are designed so that they may be adjusted in or out to increase or decrease throat depth as may be required.



To weld a part such as a cylindrical tank, the unit is slipped over the lower arm to desired location for welding, the unit resting on the lower electrode. Pressing the control actuates the hydraulic welding gun, bringing the upper electrode down against the part to be welded, and initiating the weld cycle.

● The new $1,500,000 atom smasher being built at Berkeley, Calif., will require 4,900 tons of steel. All this will be welded construction using the shielded arc process, reports *Lincoln Electric Co.*, Cleveland.

Record Rolling-Mill Bearings

The 4 tapered roller bearings installed on the rolls in the new Aluminum Co. of America mill at Alcoa, Tenn., are reported by *Timken Roller Bearing Co.* to have 30% more capacity than any bearings built before.

These bearings with a 35½-in. bore, a 51-in. outside diam., and a 36-in. width, weigh 9,070 lbs. each and have a mill separating force capacity of 8,300,000 lbs. at mill speed.

"Dry" Oils for Industrial Use

Oils containing colloidal graphite and designed for high temperature lubricating (above 400 deg. F.) have been added to the line of industrial lubricants by *Standard Oil Co. of New Jersey, Penna., and La.; Colonial Beacon Oil Co.;* and *Penola, Inc.*

Under the high temperatures for which the lubricants are designed, the oil gradually vaporizes, leaving no residue from the oil itself but only a fine film of "dry" colloidal graphite.

Under friction and heat this graphite film is adsorbed by the surface material, forming what is known technically as a graphoid surface. Lubrication from that point on is entirely "dry" until the supply of oil is renewed. Thus, the graphite prevents actual metal-to-metal contact until a new supply of oil reaches the bearing surfaces.

The oils may be applied by any of the conventional methods, including spray, oil can, mechanical lubricator, pressure gun, etc., depending on the design of equipment and operating conditions.

Expansions—Plant and Laboratory

A fourth major building expansion program in recent years is under way at *Battelle Memorial Institute,* Columbus, Ohio, where a 160,000-dollar addition to the process metallurgy laboratory building is under construction, Clyde E. Williams, Institute director, has announced. Additional space demands of enlarged research programs concerned with the study of chemical and metallurgical processes on a pilot-plane scale will be provided for when the new structure is completed.

The expansion is the result of a continued increase in the Institute's research for industry, particularly in the field of coal preparation, raw materials beneficiation, hydrometallurgy, pyrometallurgy, electrometallurgy and foundry practice.

To help meet a heavy increase in the nation's demand for airplane valve steel in 1942, *Allegheny Ludlum Steel Corp.,* Pittsburgh, is undertaking an immediate expansion of its Watervliet, N. Y. plant, according to an announcement made recently by officials.

The expansion was decided upon when government officials indicated recently that the demands of U. S. aviation plants for vital valve steel will probably be doubled by the middle of 1942.

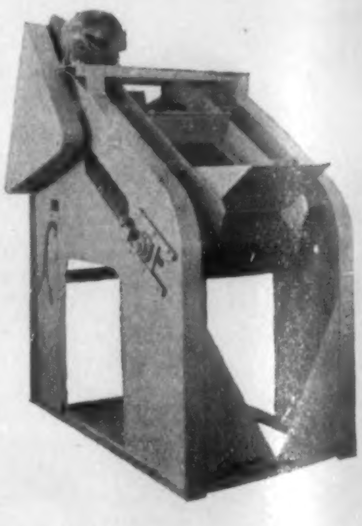
Accordingly, the hammer shop, an important unit for producing valve steel at Allegheny Ludlum's Watervliet plant, is being expanded approximately 160 ft. Six new oil-fired, electrically controlled ingot furnaces, a new 12,000-lb. hammer and a charging machine to carry ingots between the units will be installed. The expansion is the second during the past year.

The Wheelco Instruments Co., Chicago, has announced its third major expansion since 1935. The continuous increase in the volume of business has warranted this move, which will enable them to increase all of their facilities.

Reclamation of Weld-Rod Coating

A specially designed magnetic separator for reclaiming scrap welding rod coating has been put on the market by *Stearns Magnetic Mfg. Co.* of Milwaukee.

Rod coating is usually contaminated with small pieces of iron, rust and scale. The



separator does the job of removing this foreign matter. The material is fed through a spout onto a fast-moving short belt conveyor set at an angle of 30 deg. It is equipped with skirt boards to prevent spillage and a leveling device to maintain uniform depth of material.

The material leaves the belt at high velocity and hits a heavy, non-magnetic screen, which separates the fine from the coarse material before it reaches the spout ahead of the magnetic drum.

Electroplating

The Benwood Linze Co., St. Louis, Mo., announce the addition of B-L dry plate rectifiers for electroplating to their established line of rectifiers and rectifier equipment.

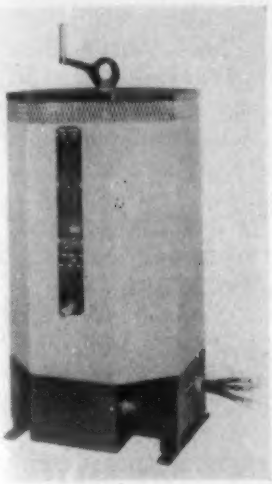
The dry plate rectifiers, it is said, are flexible and economical in operation. They will serve individual tanks; or a number of units may be grouped together in parallel to meet the demands for heavy current loads; or the units may be grouped in series for maximum high voltage requirements.

The rectifiers are assembled in cabinets, as complete units, less controls. They are compact and mobile. Models are available for 300-amp. and 500-amp. capacities, at 6 and 12 v., operating from 230 and 440 v., 3-phase, 60-cycle, a.c. service.

● Spray painting equipment, according to *DeVilbiss Co.*, is being used to spray the engines of United States fighter planes and bombers with an anti-corrosive compound containing caster oil. Other uses to which spray painting equipment is put include spraying protective coatings both inside and outside the planes, spraying non-reflecting paint on nacelles and propellers, to prevent glare, and the application of sound deadeners to kill motor vibration.

Arc Welders

A new line of a.c. transformer welders in 300, 500, 750 and 1,000 amp. capacities has just been announced by *Wilson Welder & Metals Co., Inc.*, New York. These welders, known as Model TW, are designed to meet the heavy arc welding needs of shipyards, railroads and steel mills.



The units are completely self-contained and are said to have a wide range of current output and continuous step-less current regulation provided over the entire range by means of a handcrank on top of the machine.

● Cash prizes totaling $200 or more every month are being offered for interesting news items about arc welding applications in a contest being sponsored by *Hobart Brothers*, Troy, Ohio. A first prize of $100, second of $50, third of $25, fourth of $15 and fifth of $10 is distributed every month. Additional special awards from $1 to $10 are awarded entries deemed worthy of purchase by contest judges.

Binocular Microscope

A new Spencer binocular microscope, recently put on the market by *George Scherr Co.*, New York, has been designed to improve and speed up inspection work.

This microscope will reveal flaws, surface characteristics and imperfections that cannot be seen with ordinary microscopes showing one plane of vision.

● Metal articles finished by oxidation processes may be made resistant to corrosion by immersion in a solution of "Hydrowax Liquid N Light," according to *Glyco Products Co.*, Brooklyn, N. Y. In general, the solution may be diluted to the extent of one part to 3 parts of water, but where unusually high resistance to atmospheric corrosion is desired, it may be used without dilution.

News of Metallurgical Engineers

H. J. Huester, formerly connected with the Bureau of Aeronautics of the Navy Department, is now with Reynolds Metals Co., Richmond, Va. as coordinator of defense production for the aviation industry. . . . *D. G. Baxter* has been appointed general superintendent in charge of Copperweld Steel Co.'s Warren, Ohio plant.

C. E. Wright, for the past 5 years managing editor of *The Iron Age*, is leaving that publication to become vice-president of the Charles Dreifus Co., Philadelphia and Pittsburg. . . . *Charles F. Hammond* has resigned his position of superintendent of the Cartridge Div. of the Winchester Repeating Arms Co., to become assistant to the president of the A. F. Holden Co., New Haven, Conn.

Andrew W. Liger has joined the research staff of Battelle Memorial Institute, Columbus. He was formerly associated with W. B. Jarvis Co., Grand Rapids, Mich. . . . *C. B. Voldrich*, formerly with the Navy's Bureau of Ships, has also become a member of the technical staff at Battelle Memorial Institute as a welding research engineer.

Lincoln R. Scafe, until recently general manager of the Fisher Div. of General Motors Corp. at Cleveland, is now general manager of the Glenn L. Martin-Nebraska Co.

Welded Cracking Tower

A 25 ft. by 90 ft. bubble tower was built by a Texas refinery recently for the production of high-octane gasoline for our growing air force.

In this tower, the crude oil is separated into individual components by vaporization or condensation. Most crudes contain hydrogen sulphide, which causes excessive corrosion on ordinary steel where the operating temperature exceeds 400 deg. F.

In the construction of this particular tower, as described by *Hobart Brothers Co.*, Troy, Ohio, 25-20 stainless steel lining was used. The outer shell is firebox quality steel, and the alloyed lining is fused to the shell by spot welding. All seams were single vee butt welded, the shell being welded first from the inside and 2 passes made with stainless steel rod, which sealed off all parts of the outer shell from the corrosive elements within.

● As an aid in relieving the present scrap crisis, the *Linde Air Products Co.* has developed a method of removing abandoned street-car tracks with a portable, oxyacetylene cutting machine.

Meetings and Expositions

Technical Association of the Pulp and Paper Industry. Ann Arbor, Mich. Sept. 17-19, 1941.

Association of Iron & Steel Engineers, annual convention. Cleveland, Ohio. Sept. 23-26, 1941.

Society of Automotive Engineers, national tractor meeting. Milwaukee, Wis. Sept. 25-26, 1941.

American Mining Congress, annual metal mining convention and exposition. San Francisco, Calif. Sept. 29-Oct. 2, 1941.

Electrochemical Society, semi-annual meeting. Chicago, Ill. Oct. 1-4, 1941.

Power & Mechanical Engineering Exposition, Chicago, Ill. Oct. 6-11, 1941.

American Society of Mechanical Engineers, fall meeting. Louisville, Ky. Oct. 12-15, 1941.

American Society of Tool Engineers, semi-annual meeting. Toronto, Canada. Oct. 16-18, 1941.

American Welding Society, annual meeting. Philadelphia, Pa. Oct. 19-23, 1941.

American Gear Manufacturers Association, semi-annual meeting. Chicago, Ill. Oct. 20-22, 1941.

American Institute of Mining & Metallurgical Engineers, fall meeting of Institute of Metals Div. and Iron & Steel Div. Philadelphia, Pa. Oct. 20-22, 1941.

American Gas Association, annual convention. Atlantic City, N. J. Oct. 20-24, 1941.

American Society for Metals, annual meeting. Philadelphia, Pa. Oct. 20-24, 1941.

National Metal Congress and Exposition. Convention Hall, Philadelphia, Pa. Oct. 20-24, 1941.

Wire Association, annual meeting. Philadelphia, Pa. Oct. 20-24, 1941.

WANTED

several ELECTRIC INDUCTION AND ARC FURNACES any size. Box MA-25.

FREE SERVICE DEPARTMENT

Replies to box numbers should be addressed care of METALS AND ALLOYS, *330 W. 42nd. St., New York.*

METALLURGIST WANTED: Young, competent metallurgist with two or more years of commercial experience in heat treating and steel analysis. Plant located in Union County, N. J. Working conditions and equipment are excellent. Box MA-26.

METALLURGICAL ENGINEERING

shop notes

Furnaces for Tool Hardening

by Walter A. Schlegel
Carpenter Steel Co.

In two previous articles on hardening tool steels (August 1940, page 226, and December 1940, page 836), we stressed the desirability of having a slightly "oxidizing" atmosphere for hardening certain tool steels and outlined some simple, practical methods of checking atmospheres for specific steels.

Atmosphere practice is, of course, considerably affected by the *type of furnace* used for tool hardening. The comments that follow are, therefore, intended to indicate the main "atmospheric" features of the furnace-types with which the heat treating engineer is concerned.

In an electric muffle furnace with nothing but the room atmosphere, this atmosphere will *not* remain constant when a tool steel charge is inserted and the furnace closed, but will gradually become decarburizing.

One way to counteract this is to put a small hole in the bottom and another in the top of the furnace, so that a slow draft of air will flow through the furnace. The resulting "atmosphere," although scaling, will not be decarburizing to those tool steels that require an oxidizing atmosphere (see the August 1940 issue).

An optional corrective is to insert a small Bunsen gas burner in the bottom of the furnace, put a vent in the roof, and control the atmosphere by adjusting the burner and testing with wood blocks, gas torch or a lump of soft coal (according to the type of steel treated) as outlined in the previous articles.

With electric muffle furnaces of the gas curtain type, it is easy to operate on the oxidizing side and then determine the atmosphere by the wood block (or soft coal) method. When the manometers on such a furnace have once been calibrated, the proper atmosphere can be duplicated at will by returning to the same manometer settings as originally established.

Gas fired semi-muffle furnaces are, of course, excellent for this type of hardening, especially on the oxidizing side. A practical essential is to have an *inspirator* installed, if one is not already attached. This is an inexpensive device sold by furnace and accessory manufacturers to mix the gas and air before it enters the furnace.

An adjusting screw is provided to control the mixture to any degree of oxidizing or reducing. Also, when an inspirator is used, only one valve is needed to control the furnace temperature, and the atmosphere is not changed every time furnace temperature is adjusted.

Oil-fired semi-muffle furnaces are very satisfactory for those tool steels that require an oxidizing atmosphere. It should be remembered that the appearance of a flame at the ports is not necessarily an indication of a reducing atmosphere with oil-fired furnaces. Wood blocks should be used to check the atmosphere.

Controlling both temperature and atmosphere by means of *two* separate valves (oil and air) is as difficult with oil-fired as with gas-fired furnaces. Some oil burners on the market automatically maintain a constant oil-air ratio and allow the temperature to be controlled by a single lever.

Pure carbon muffles are available for tool hardening. They generate their own atmosphere from the partial oxidation of the muffle. This atmosphere tends to approach about 34% CO, and is probably a reasonably pure mixture of carbon monoxide and nitrogen. These muffles are normally used for hardening temperatures between 1700 deg. and 2400 deg. F., and will produce work free from decarburization or scale within this range.

Precautions in Handling Carbide Tools

by James R. Longwell
Carboloy Co., Inc.

In view of the tremendous increase in usage of carbide cutting tools and the large number of newly trained men being employed, particularly in connection with speeding defense production, we are reproducing herewith a table of simple "do's" and "don't's" to remember in connection with such tools.

While these precautions do not cover all carbide problems, their observance will assist engineers in charge of tool departments and machine operations in vastly reducing tool spoilage and breakage, and improving performance.

AVOID	IF POSSIBLE
Avoid using rocker support under tool	Use flat, rigid base
Avoid setting tools excessively above or below center line	Set tools of approximately 1/32 in. of center line
Avoid use of hammer on cutting end of tool	If necessary, set tool short of desired length and adjust from rear
Avoid use of inclined tool holders	Use tool-holders designed to hold tool on horizontal plane
Never have tool against work when tightening clamping screws	Back out tool when tightening clamping screws
Avoid use of pointed clamping screws	Use dog-point or flat clamping screws
Never leave excessive overhang	Cut overhang to minimum
Never dip tool in any liquid while tool is hot	Always allow tool to cool naturally
Never use weak stream of coolant	Use generous coolant flow. If possible force coolant *under* chip and against cutting edge
Never stop spindle before disengaging feed	Always disengage feed before stopping spindle
Never use "any old wheel" for grinding carbide tips	Always use silicon carbide or diamond wheels for grinding tip
Never run a carbide tool until it won't cut any more	Sharpen carbide tools at regular intervals to get longest life
In grinding carbide tips, don't hold tool motionless against the wheel	Keep tool moving across wheel when grinding to avoid localized overheating

(Continued on page 342)

If tools chatter, look for:

(1) Excessive tool overhang
(2) Insufficient end cutting edge angle
(3) Too large a tool nose radius
(4) Insufficient feed
(5) Too much tool clearance (tool relief angles)
(6) Rake angles too large (decrease as a last resort)
(7) With hand feed on plunge cut tools (grooving, cut-off, etc.) increase rate of feed in proportion to increase in rate of speed. (Example: If you double the speed, double the rate of feed.)

If tools wear rapidly, look for:

(1) Insufficient feed, causing rubbing action
(2) Insufficient clearance (tool relief angles)
(3) Excessive chatter and vibration

To facilitate inspection of repair-weld jobs on cracks in hard-to-see places, simply paint over the welded area with aluminum paint. It will then be easy to see if the welded spot has cracked or checked.

—*The Stabilizer,* Lincoln Electric Co.

Bronze-Welding Cast Iron to Steel

by E. Grigis
Linde Air Products Company

An effective and economical procedure for bronze-welding steel to cast iron is demonstrated in the fabrication of a type of piston ring designed to provide positive sealing action and thus to prevent loss of compression within the cylinder.

The feature of this ring is a lug which is welded to one end of the piston ring in such a way as to act as a tongue to cover the gap in the piston ring at all times as it expands and contracts against the cylinder wall during the movement of the piston. In the bronze-welding of this lug (which is of steel) to the ring (made of nickel cast iron) the use of a flux containing finely-divided spelter not only speeds the tinning action, but also reduces the amount of rod and flux necessary.

Prior to the present procedure for joining the steel lug to the cast iron ring, several methods of soldering, brazing, and welding with a cast iron rod had been attempted. Cast iron welding had produced hardened spots that were difficult to machine, while soldering and the method of brazing employed had resulted in excessive use of rod and heating time.

However, by using a special cast iron brazing flux, (Oxweld cast iron brazing flux) which, with its low-melting-point spelter, overcomes the tendency of a nickel-iron base metal to resist the bronze-welding action, and bronze welding rod, the operating time per ring was reduced from 3-5 min. to 28 sec. Only 1 in. of $1/8$-in. rod and a small amount of flux are necessary per ring. Such a bronze weld has a greater strength than that of the cast iron base metal, and the bronze strip left on the outside of the finished lug provides a better anti-friction area than does the cast iron. Moreover, the excess bronze deposit is easily machined during the finishing operations.

The flux is thoroughly mixed with water and applied to both the underside of the lug and the insert surface of the piston ring. Lug and ring are then clamped together in a suitable jig. One operator, using a blowpipe with a No. 8 head, heats the top side of the lug, while a second operator, using a similar blowpipe, heats the outside area of the ring.

The spelter in the flux melts at a comparatively low temperature. When the spelter begins to flow, the bronze rod is added by the first operator. Melting at a higher temperature, the bronze begins to flow into the seam between the lug and the ring, displacing the spelter, and, when it appears that the bronze is flowing through, the second operator removes his flame.

On completion of the bronze-welding operation, each ring is first rough-machined. It is then placed on a mandrel for holding 12 or more rings for finish-machining.

For machining plastics, one company reports that hard aluminum bronzes (e.g. Grade 20 Ampco Metal) have proved very satisfactory for tool bits. In one case, an aluminum bronze tool bit was in as good condition after facing and turning a $2\frac{1}{2}$ in. o.d., 2 in. long plastic cylinder, as before.

—Ampco Metal, Inc.

Now that the summer is over and the mermaids, mint-juleps and mosquitoes are mere memories, you must have quite a collection of practical, time-saving, trouble-saving or money-saving ideas that you haven't sent to this department yet.

Remember, we pay for all original SHOP NOTES published. Maybe it isn't exactly a windfall, but it does help with the taxes!—The Editors.

Solder in Granular Form

by L. Kasper
Steel Heddle Mfg. Co.

Very often for both shop and experimental purposes, a quantity of solder in finely granular form is required. Filing the solder to produce such material is ordinarily too expensive. The following unique method has been employed by us for such work.

The solder is melted in a ladle and then permitted to cool almost to the freezing point, but not sufficiently to prevent pouring. A piece of closely woven cloth is spread over the open end of a box, and then pushed down into the box to form a receptacle into which the solder is poured.

Then, the ends of the cloth are held with one hand to form a rudimentary bag with which the solder is lifted out of the box. With the cloth held in one hand, as shown in the illustration, the semi-molten solder is kneaded with the other hand, which is protected with a glove.

The kneading is continued until the solder has cooled, and results in the formation of fine granules. The coarser particles can be screened out for re-melting.

Although this method is one that may not occur to the average user, there is nothing mysterious or startling about it. The agitation of kneading merely prevents solidification in one mass but permits solidification in small particles.

Strong caustic cleaners should never be used in the cleaning of shells, shell cases, cartridge cases, etc., not only because they are hazardous, but also because they stain copper, preferentially remove zinc from brass, cause pitting, are difficult to rinse and may result in the formation of unstable alkaline picrates within the shell.

—"Munitions Cleaning Handbook," Magnus Chemical Co., Inc.

Stress-cracks developed in the deep drawing of rapid-work-hardening materials like Monel, Inconel, nickel, etc., may be avoided by leaving a small flange to reinforce the rim of the shell, particularly with hard-temper blanks. Rough edges on the blanks, and wrinkles formed about the rim during early draws, are other causes of stress-cracking.

—*Bulletin T-19,* International Nickel Co., Inc.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Design and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms: Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

1 Production
OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials Manufacture of Die Castings.

Oxygen in Nickel-Bearing Melts

THE ACTION OF OXYGEN ON IRON-NICKEL AND COPPER-NICKEL MELTS ("Ueber die Einwirkung von Sauerstoff auf Eisen-nickel- und Kupfer-Nickel-Schmelzen") C. VON BOHLEN U. HALBACH & W. LEITGEBEL. *Tech. Mitt. Krupp, Forschungsber.*, Vol. 4, Apr. 1941, pp. 37-44. Research.

The behavior of iron-nickel and copper-nickel melts was studied when oxygen was blown on to their surfaces at 2200°-2400° F.; at these temperatures the reaction of oxygen with the melt takes place very rapidly. The miscibility gap extending from the system $Fe-FeO$ is closed in the range $Fe-Ni-NiO-FeO$ only shortly before reaching the partial system $Ni-NiO$. Iron could be removed from iron-nickel melts down to about 0.13% in this manner.

The capacity of liquid iron-nickel alloys to dissolve oxygen corresponds practically to that of pure iron. The small quantities of dissolved carbon are precipitated during solidification along the grain boundaries. The solubility for oxygen increases rapidly only for less than 1% Fe. An alloy with 2.1% Fe and 0.73% O_2 has an almost purely eutectic structure.

The miscibility gap starting from the liquid system $Cu-Cu_2O$ extends into the concentration range $Cu-Ni-NiO-Cu_2O$ up to a content of 40% Ni. The solubility of copper for oxygen was found to be at least 2.5% at the temperature of the monotectic. The solubility of liquid copper with about 20% Ni for oxygen corresponds approximately to that of pure copper.

With increasing nickel content, the solubility for oxygen increases and is at 30% Ni about 5%. An accumulation of nickel in the liquid copper-nickel-oxide phase is possibly only beyond 65% Ni in the starting alloy because of the greater affinity of nickel for oxygen. Ha (1)

1a. Ferrous

Blast Furnace Developments

"TECHNICAL PAPERS OF THE AMERICAN IRON & STEEL INSTITUTE." *Blast Furnace & Steel Plant*, Vol. 29, July 1941, pp. 710-711. Conference report.

The program of one of the technical sessions of the general meeting of the Am. Iron & Steel Inst., held recently in New York City, comprised a series of brief question and answer papers. Two of these questions are reviewed here.

The first one discussed was: "What are the principal factors that affect the life of a blast furnace lining, and what improvements have been made that have prolonged furnace lining life?"

Mr. Wm. A. Haven, of Arthur G. McKee & Co., discussed this question. The most serious cause of lining failures at one time was probably faulty distribution of ore, coke and limestone on the top of the stacks when charging with the earlier types of skips and buckets. The trouble was solved by perfecting the design of top charging equipment. The steady advancement in all phases of coke manufacture have also improved the distribution of stock in the furnaces.

Breakouts are now rare owing to improvements such as better coke and refractories, better hearth and bosh design, better application of hearth and bosh cooling, and better casting equipment.

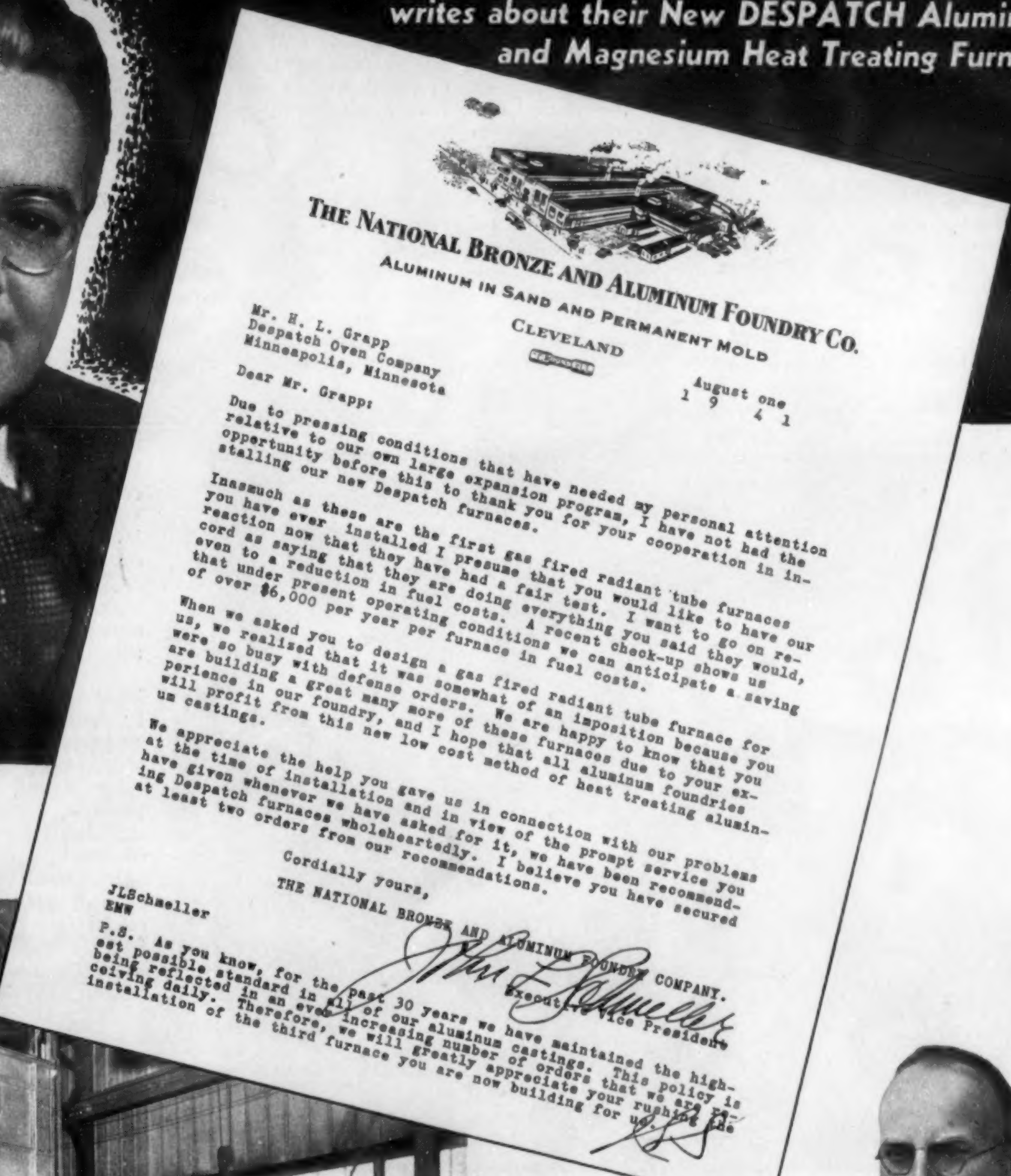
The brick manufacturers have solved the problem of chemical disintegration of brickwork. However, the best linings are affected by the skill of the brick masons, weather conditions when installed, provisions made for expansion, and carefulness of the management in the drying-out, blowing-in and blowing-out periods.

Other factors affecting the lining life are the use of excessively basic or acid slags and the practice of hard driving or overblowing.

The life of a furnace lining expressed by tons of metal produced has greatly increased since 1880. Then, a run of 105,000 tons was a record; now, several furnaces are reported to have made more than 1,500,000 tons and are still not worn out.

The second question, discussed by E. R. Miller, was: "What results have been obtained by conditioning the air used in blast furnaces?" No definite statements can be made on the results obtained from the air conditioning of blast furnaces. Air conditioning equipment was installed at the Woodward Iron Co. in 1939. The equip-

MR. SCHMELLER, Executive Vice President of the National Bronze and Aluminum Foundry Co. of Cleveland, Ohio, writes about their New DESPATCH Aluminum and Magnesium Heat Treating Furnace.



THE NATIONAL BRONZE AND ALUMINUM FOUNDRY CO.
ALUMINUM IN SAND AND PERMANENT MOLD
CLEVELAND

Mr. H. L. Grapp
Despatch Oven Company
Minneapolis, Minnesota

August one
1 9 4 1

Dear Mr. Grapp:

Due to pressing conditions that have needed my personal attention relative to our own large expansion program, I have not had the opportunity before this to thank you for your cooperation in installing our new Despatch furnaces.

Inasmuch as these are the first gas fired radiant tube furnaces you have ever installed I presume that you would like to have our reaction now that they have had a fair test. I want to go on record as saying that they are doing everything you said they would, even to a reduction in fuel costs. A recent check-up shows us that under present operating conditions we can anticipate a saving of over $6,000 per year per furnace in fuel costs.

When we asked you to design a gas fired radiant tube furnace for us, we realized that it was somewhat of an imposition because you were so busy with defense orders. We are happy to know that you are building a great many more of these furnaces due to your experience in our foundry, and I hope that all aluminum foundries will profit from this new low cost method of heat treating aluminum castings.

We appreciate the help you gave us in connection with our problems at the time of installation and in view of the prompt service you have given whenever we have asked for it, we have been recommending Despatch furnaces wholeheartedly. I believe you have secured at least two orders from our recommendations.

Cordially yours,

THE NATIONAL BRONZE AND ALUMINUM FOUNDRY COMPANY.

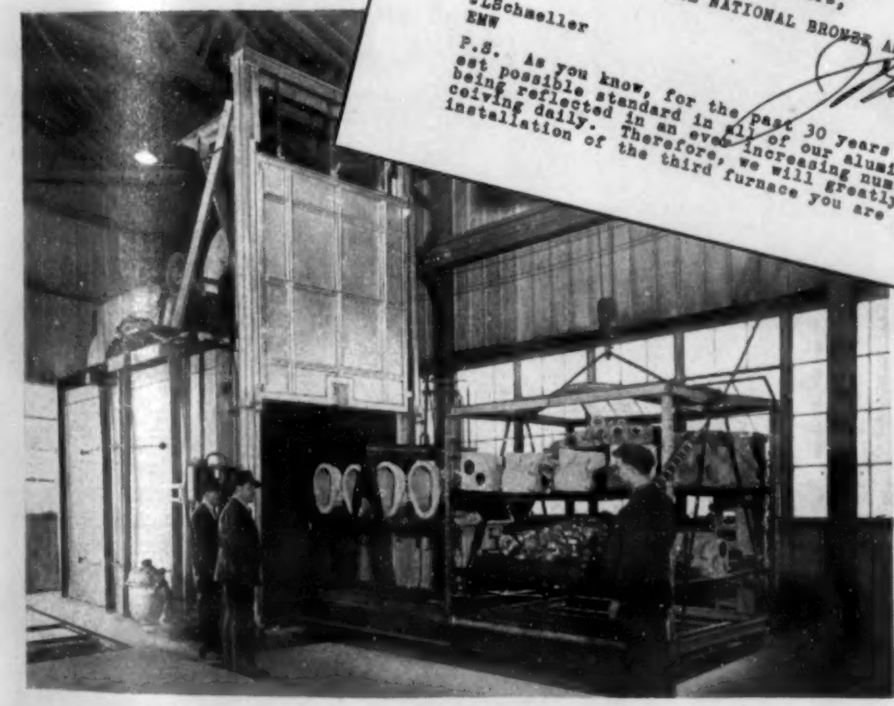
John L. Schmeller

Executive Vice President

JLSchmeller
EMW

P.S. As you know, for the past 30 years we have maintained the highest possible standard in all of our aluminum castings. This policy is being reflected in an ever increasing number of orders that we are receiving daily. Therefore, we will greatly appreciate your rushing the installation of the third furnace you are now building for us.

J.L.S.



A Despatch Car Loading Type Furnace, one of a battery operating at the National Bronze and Aluminum Foundry Company plant in Cleveland, Ohio. This furnace accommodates up to 10,000 pounds net load per charge. The work chamber measures 8' x 7' x 15'. Despatch Aluminum and Magnesium Heat Treating Furnaces are built to any size requirement necessary. Prompt delivery is maintained

"Thank you, Mr. Schmeller. The industry will be interested in your statement about the Despatch aluminum and magnesium heat treating furnace accuracy, uniformity and fuel economy. Despatch stands ready to serve you and the industry in your national defense efforts.

Mr. H. L. Grapp, Vice President, Despatch Oven Company

Write for new Bulletin No. 81 E. The new Despatch Aluminum and Magnesium Heat Treating furnace features are diagrammed and illustrated with photographs of recent installations.

DESPATCH
OVEN COMPANY MINNEAPOLIS, MINNESOTA

ment was set to maintain the moisture content in the blast constant at 3 grains per cu. ft. Marked improvement in operation was noted.

An installation was made on a large Aliquippa furnace. The daily iron production was approximately 5% better, and the coke consumption was 3% less. Normal coke quality was not available for these tests, and it is expected that the equipment will permit an increase of about 9% in iron production. (1a)

Making Steel Castings

"The Production of Steel Castings." C. H. Kain. *Foundry Trade J.*, Vol. 64, June 19, 1941, pp. 411-412; June 26, 1941, pp. 429-430. Descriptive.

Plain ladles can be used with acid steel if the lining is thick and adequately preheated. It is usual to form a bridge of slag at the lip, through which the metal is poured. This bridge may be formed by the addition of sand or by using a fireclay brick.

Plain ladles are not successful with basic steel as the slag cannot be controlled. Teapot ladles are used successfully if the spout is large enough and if pouring from the ladle is frequent or continuous. Otherwise the teapot is not very successful as the spout tends to freeze up. The bottom-pour ladle is in most general use, the metal being poured through the nozzle at the bottom of the ladle which is opened and closed by a refractory plug.

Four methods of molding are in common use, green sand, dry sand, oil sand and "compo." No coal dust or similar matter is used in steel sands, and permeabilities are consequently much higher. "Compo" consists of a very strong mixture of refractory materials such as crushed firebrick, silica sand, carbon, old crucibles etc., bonded with fireclay.

In the case of open heads, feeding compounds are frequently employed. These usually either lower the melting point of the metal in the head through carbon absorption, or form an insulating layer that prevents cooling of the top surface of the feeder. Most of these feeding compounds are made from powdered carbon, aluminum and calcium silicide, but chopped chaff or straw has been used very successfully, especially on large headers. AIK (1a)

Superheating of Cast Irons

"Some Factors Influencing the Graphitizing Behavior of Cast Iron." S. C. Massari & R. W. Lindsay. *Am. Foundrymen's Assoc.*, Preprint No. 41-7, May 1941. Research.

The effect of maximum melting and pouring temperatures on graphitizing behavior was investigated in an iron containing 3.60% T.C and 0.55% Si. An increase in the maximum temperature to which the molten metal is heated causes an increase in the depth of chill in a chilled casting. This is shown to be due to the progressive solution of graphite nuclei, which, had they remained, would act as centers of precipitation of graphite during subsequent solidification.

When the maximum temperature of the iron does not exceed approximately 2700° F., decreasing pouring temperatures produce a decreasing depth of chill and a refinement of the mottled zone in a reasonably large casting such as a car wheel. Apparently, the comparatively slow cooling of the metal in the ladle permits precipitation of graphite nuclei, which act to cause precipitation of more graphite upon solidification. Cooling in the mold suppresses nuclei formation and consequently pouring from the higher temperatures yields a greater depth of chill.

Iron that has been melted at temperatures in excess of 2700° F. exhibits a decrease in depth of chill and in hardness of the mottled areas as the pouring temperature is decreased. Iron melted at such temperatures is particularly hard to control, since the subsequent pouring temperature exerts a more pronounced influence on the depth of chill. This type of iron is characterized by a coarsely dispersed mottled zone.

Care must be exercised in controlling chill depth by controlling pouring temperature since it is necessary to pour at temperatures consistent with sound castings.

Nucleation, by the introduction of an extraneous source of graphite into the molten iron, was studied. Such treatment markedly affects graphitizing behavior, reducing the depth of chill and causing a sharp transition from chilled to gray iron.

An extraneous source of graphite in contact with the molten iron serves to introduce nuclei that act to reduce the depth of chill and narrow the mottled zone. Such graphite inoculation is so potent that it is necessary to compensate for it by the simultaneous use of a strong carbide-stabilizing element, such as chromium or tellurium. CMS (1a)

Fluidity of Steels

"The Fluidity of Ingot Iron and Carbon and Alloy Cast Steels." H. F. Taylor, E. A. Rominski & C. W. Briggs. *Am. Foundrymen's Assoc.*, Preprint No. 41-11, May 1941. Experimental.

Studies are presented on the fluidity of cast steel as measured by various types of

TYGON

OUR LABORATORY TESTS PROVE THAT TYGON PAINT POSSESSES THE GREATEST GENERAL RESISTANCE TO CORROSIVE ATTACK OF ANY PAINT MADE –

BUT

Make these convincing tests yourself!

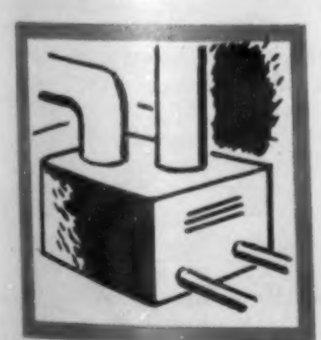
WITHOUT COST OR OBLIGATION TEST TYGON PAINT IN YOUR OWN PLANT SEND TODAY FOR MULTICUP TEST SAMPLE

TYGON — the base from which TYGON paint is made — is widely used as a lining for tanks in which corrosive substances are made and handled. For paint, TYGON is liquified by the addition of volatile solvents, which on evaporation, leave a strong, durable film of chemically unchanged TYGON.

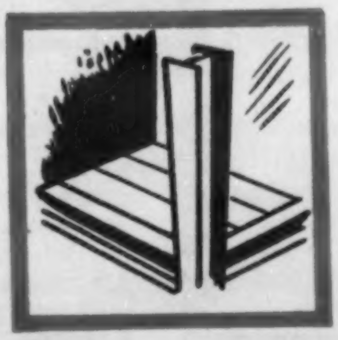
TYGON paint can be used economically and effectively wherever surfaces are exposed to the attack of corrosive fumes or condensates, or subjected to occasional spillage.

But test it yourself—send today for the multicup testing sample and put it through any tests you like. No cost — no obligation.

Write
Synthetics Division
THE UNITED STATES STONEWARE CO.
Akron, Ohio



SHOP EQUIPMENT
TYGON paint stops deterioration from corrosion or rust. Ideal for equipment handling corrosive materials.



WALLS AND STRUCTURAL STEEL
TYGON paint prevents rapid destruction from fumes and condensates. Invaluable in pickle or plating rooms.

FLOORS
TYGON floor paint provides a hard surface unaffected by fumes or spillage — easy to clean — long wearing — no peeling.

TEMPORARY PROTECTION
TYGON primer alone gives excellent temporary protection for structural work. Ideal for shopcoats.

TYGON *Corrosion-Proof* LININGS • PAINT TYGON

test pieces, including the spiral fluidity mold, which was found to give the most accurate and dependable results.

The experimental technique, designed for as complete a control of variables as possible, is described in detail. A testing procedure is outlined whereby it is possible to use the spiral fluidity mold effectively at the furnace for determining proper tapping times.

The preparation of the test mold, that is, whether it is made of cement-sand or green or dried sand (bentonite-bonded) has no influence on the fluidity of cast steel as measured by the spiral. The length of spiral, when cast in naturally-bonded, green sand molds, is consistently longer than when cast in naturally-bonded, dried sand molds. Mold washes decrease the length of spiral slightly but give better reproduction of the mold cavity.

Temperature is a very important factor in governing the flowing power of steel. Its relationship to fluidity is clearly shown for many compositions. Carbon content was found to affect fluidity to a small degree only. The effect of deoxidation, as governed by the amount of deoxidizer added, indicates that a certain critical amount of oxide is necessary for maximum fluidity.

The basic influence upon fluidity of elements, added for their alloying effect, is shown to be a function of the individual element and follows no predictable rule. Within the limits of the experiments, molybdenum, vanadium and chromium decreased somewhat the running quality of the steels to which they were added, while copper and nickel increased it. It was found essential that silicon be maintained above a critical value, or supplemented by a suitable deoxidizer, in the interest of fluidity as well as soundness.

Manganese, in the amounts usually employed in plain carbon steels, does not increase fluidity at normal pouring temperatures. When used in customary amounts in the presence of silicon, manganese neither increases nor decreases the spiral length perceptibly. When present in higher concentrations (medium manganese or Hadfield steels), manganese markedly increases fluidity at lower temperatures in proportion to the amount present. CMS (1a)

Furnace Types for Best Cast Iron

IS THE MELTING FURNACE DETERMINING FOR THE QUALITY OF CAST IRON? ("Bestimmt der Schmelzofen die Gusseisenqualität"?) E. PIWOWARSKI. *Giesserei,* Vol. 28, May 2, 1941, pp. 193-197. Review.

The question whether the type of melting furnace (cupola, electric, etc.) is of importance for the quality of the cast iron obtained from it is exhaustively treated through a survey of the literature and the author's own investigations. The results are summarized as follows:

Where the chemical composition index ($C + \frac{1}{3}Si$) is between 2.8 and 3.6%, all types of cast iron have a tendency, *independent of the kind of melting furnace,* to have low mechanical strength unless special steps are taken (by ladle additions, for example) to secure favorable graphite formation. This strength lowering is most noticeable for wall thicknesses under 1.2 in.; for wall thicknesses above 1.6 in. the deterioration of strength is less pronounced.

A further increase in both the obtainable strength and the certainty of obtaining it in the production of cast iron is possible for carbon contents between 2.4 and 2.8%, independent of the type of melting furnace. The cupola offers the best chances for further considerable development in the range of 2.8-3.6% saturation.

In the discussion, attention is called to the fact that although high quality cast iron can be produced in the cupola, it is probably more economical to do this in the electric furnace. Ha (1a)

Reinforced Cast Iron

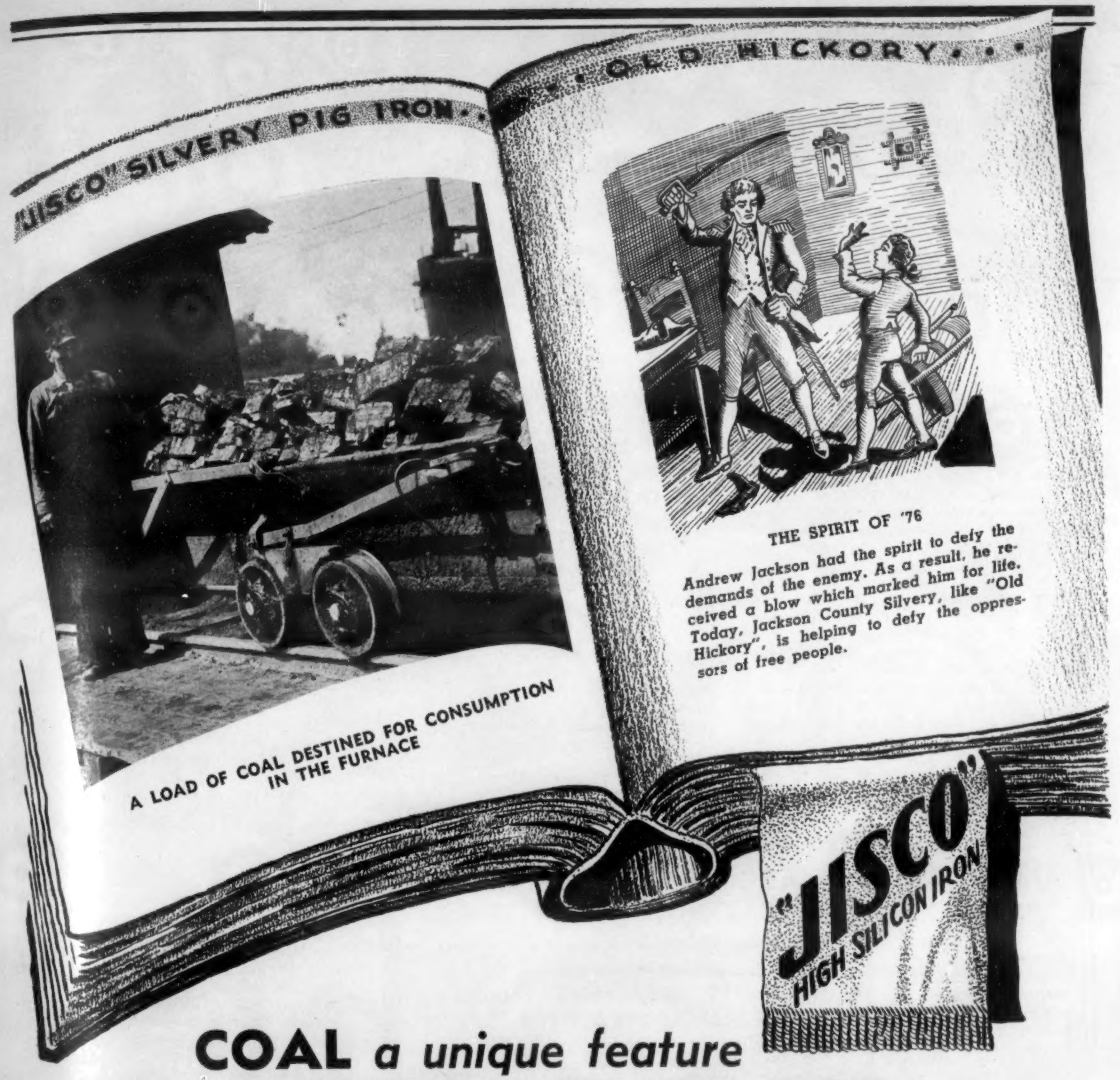
"REINFORCED CAST IRON AND ITS APPLICATIONS." N. LEVANOV. *Foundry Trade J.,* Vol. 64, May 22, 1941, p. 346. Extracted from an article in *Vestnik Metallopromyshlennosti,* No. 12, 1939, pp. 11-18.

The supporting capacity of cast iron members may be increased by incorporating in them during casting a reinforcement of mild steel bars.

Experimental work has shown that the mild steel should have a carbon content of 0.10 to 0.25%, and should have a perfectly clean surface, free from rust, scale or other contamination. The iron should be poured at a temperature of 2300° to 2516° F.

Metallographic examination shows that the diffusion of carbon from the cast iron into the steel produces in the latter a surface cementation layer, underlying which is a pearlite zone, while in the central portion the original ferrite-pearlite structure remains unaltered. In the cast iron zone immediately adjacent to the steel, the structure is that of a eutectoid steel. This is followed by a zone having a sorbitic structure, while further away from the reinforcement there is evidence of a reduction in size of the graphite flakes.

In furnace construction, where high dura-



COAL *a unique feature in producing* SILVERY IRON

JISCO Silvery is a high silicon pig iron, which contains from 6 to 17 per cent of that element. The silicon is obtained principally from silicious iron ores. In order to reduce these ores, higher temperatures and a longer soaking period are necessary.

These reactions are materially aided by the use of Jackson County Sharon Seam Coal. The coal lengthens the smelting time and assists in holding down the zone of fusion, thereby assuring the production of a high grade, uniform iron.

JISCO is one of the few blast furnaces in the world, using coal as well as coke for fuel.

THE JACKSON IRON & STEEL *Company*
JACKSON, OHIO.

bility under severe temperature conditions is required, this reinforced cast iron has been found very suitable. In structural engineering reinforced cast iron has been successfully employed for the lining sections of the Moscow underground railway.

Under test, these sections of reinforced cast iron were found to have a supporting capacity 40% greater than that of similar sections of cast iron without reinforcement.

AIK (1a)

Undercooling of Gray Iron

"NOTES ON THE UNDERCOOLING OF GRAY CAST IRON." ALFRED BOYLES & C. H. LORIG (Battelle Mem. Inst.) *Am. Foundrymen's Assoc.*, Preprint No. 41-1, May 1941. Experimental.

Experiments were conducted to determine the results of undercooling irons of the same composition.

To secure uniform conditions throughout the test, the authors placed each charge of gray iron, consisting of pieces weighing 200 gms., cut from standard transverse test bars after the outer skin had been removed, in a furnace standing at 2700° F. After each charge was placed in the furnace, it was held for 30 min. and an addition of ½ gm. of calcium-silicon was made and the melt held for 2 min. at temperature.

The metal was then removed from the furnace and cooled in air for 20 sec. and poured. The remainder of the melt was immediately returned to the furnace and held an additional 30 min. after which a second casting was poured.

Decided differences in structure were obtained in the 2 castings, the metal with the 2-min. holding time after the addition of calcium-silicon showing a greater number of rosettes than the metal held for 30 min. longer. Thermal-arrest curves were determined on both the normal and modified irons and these are shown and their characteristics described.

CMS (1a)

1b. Non-Ferrous

Aircraft Die Castings

"SOUND DIE CASTINGS FOR AIRCRAFT." HERBERT CHASE. *Iron Age*, Vol. 147, June 19, 1941, pp. 41-45. Practical.

The die casting of aluminum alloys at the Phoenix Machine Co. is described. As aluminum is affected, especially as to elasticity and elongation, by iron content, the effect of the iron content is minimized by keeping the casting temperature as low as possible, and by using the "cold chamber" type of machine in which the hot metal is in contact with the steel for only a short time.

In this method the object is to keep the alloy so close to its melting temperature that, although sufficiently liquid, it is really in slush-like form. As the metal is less liquid, more pressure is applied to force it into the die. This higher pressure seems to produce sounder castings.

To secure castings of maximum density, the following variables must be considered: (1) the alloy used; (2) temperature of metal injected; (3) rate and manner of metal flow in die; and (4) pressure applied during injection.

As to the first variable, the alloy selected is that giving the characteristics desired. Therefore, it may be necessary to experiment to find the right alloy for a certain purpose. The rate and manner of metal flow depend upon gating and direction of flow; temperature of die and of metal; size and location of air vents; section thickness of casting; and pressure applied. All these can be controlled but only by experience.

According to some authorities, the gain in density resulting from high injection pressure is not the result of high velocity of incoming metal, but is determined by the pressure actually exerted to overcome the increasing resistance to flow as the injection cycle progresses and particularly during the final period when filling of the cavity is nearing completion and rapid chilling is taking place. For this reason, among others, the design of the machine should be such that the locking pressure is ample to keep the dies tightly closed.

The machine used is of the Lester-Phoenix type, designed with rigid beam to insure positive die locking. The absence of tie bars makes the dies easily accessible. Pressure is applied by hydraulic pumps. Pressure as high as 22,000 lbs./in.² can be applied over a die cavity area of 40 in.² The same type of machine is used for die casting magnesium.

VSP (1b)

Electrolytic Manganese

EXPERIMENTS WITH THE ELECTROLYTIC DEPOSITION OF MANGANESE FROM MANGANESE CHLORIDE SOLUTIONS. G. THANHEISER & R. HUBOLD. *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch. Düsseldorf*, Vol. 23, No. 1, 1941, pp. 1-19. In German.

A survey of the literature indicated that the deposition of manganese from sulphate electrolytes is not entirely satisfactory, as sometimes the deposited material contains much sulphur. The deposition from pure manganese chloride electrolytes also was not satisfactory because of the quick deterioration of the electrolyte and the low yield of manganese.

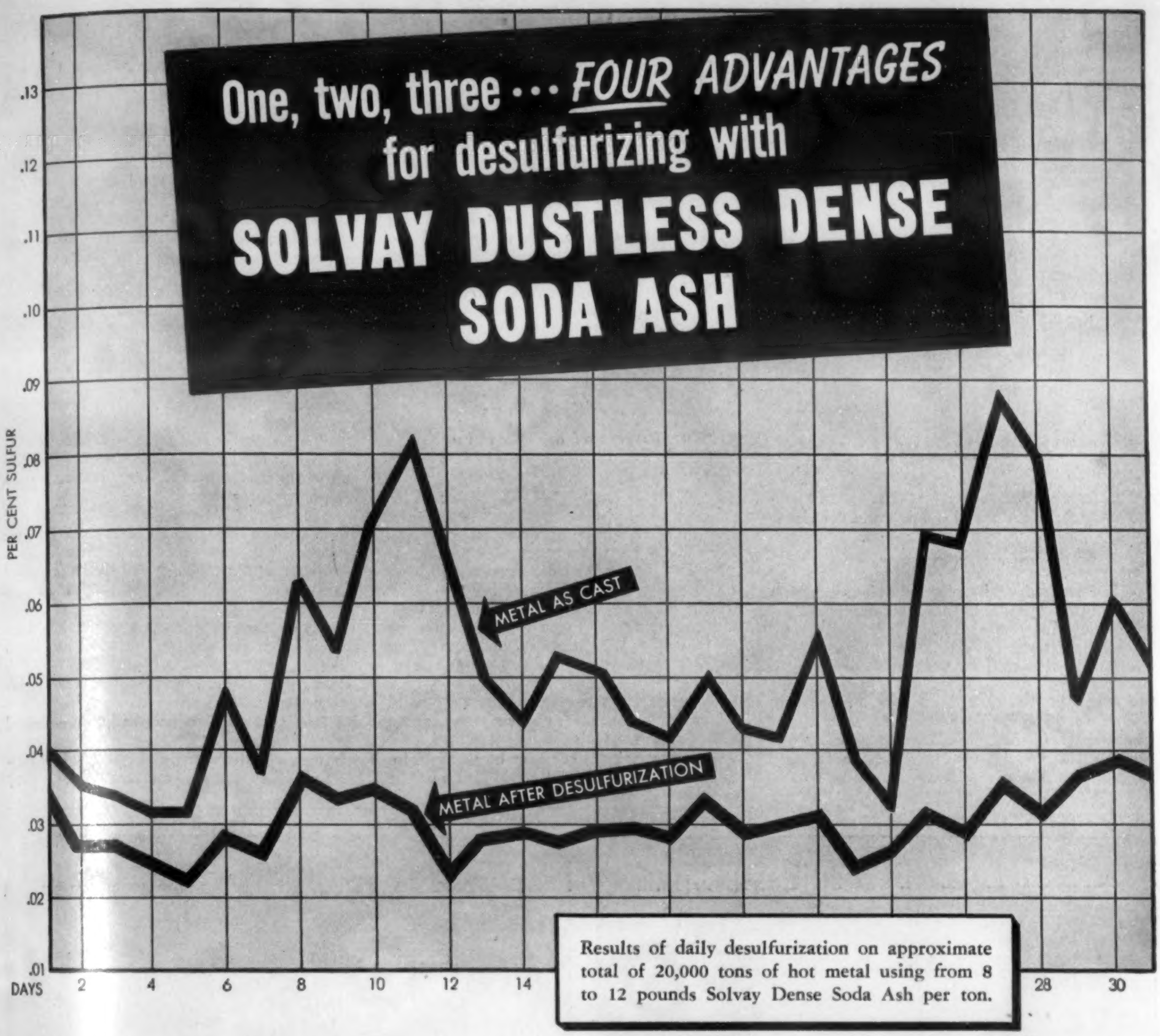
The addition of ammonium chloride improved conditions considerably; the best results were obtained with high manganese concentration in the electrolyte (47-82 g. Mn/1.) and high ammonium chloride contents (160 g./1.).

The influence of ammonium chloride concentration in the electrolyte on the results of manganese deposition is greater than the influence of the manganese concentration. Electrolytes with high ammonium chloride concentrations give even at low manganese chloride concentrations comparatively satisfactory depositions while with high manganese chloride but low ammonium chloride contents no satisfactory results could be obtained. Also, the life of the electrolyte increases with increasing ammonium chloride content.

The best current yields were obtained with 10 amp./dm.² The pH value of the electrolyte changes during electrolysis to the acid side and can be maintained in the desired range only by continuous ammonia additions. The temperature of the bath can be kept at 70° F. but even at 107° F. satisfactory manganese depositions were obtained.

The time of the removal of the deposit from the cathodes is very definite and is indicated by a characteristic discontinuity in the deposition curve; at this point the deposit starts to come off the cathode and is attacked by the electrolyte. No satisfactory deposits can be obtained without use of diaphragms, and the best results are obtained if manganese is deposited in a fine-crystalline, dense form.

Cathodes of copper can be used, but the *material* of the cathode is of less importance on the deposit than the *treatment* of the cathode (polishing, etching, etc.). Polished surfaces that are subsequently



The effective use of Solvay Dustless Dense Soda Ash for control of sulfur in hot metal external to the blast furnace—*is proven practice.* Results of actual operating tests are shown in the illustration.

Solvay Dustless Dense Soda Ash combines the following desirable characteristics:

1. It is a dense, uniform and compact product which is easy to handle.
2. It is *dustless,* resulting in minimum loss of material during handling.
3. It is a granular soda ash which flows easily, fuses quickly and mixes rapidly with molten iron.
4. It is a high purity soda ash which is the most economical commercial source of sodium carbonate. It gives the most *effective* alkali per dollar spent.

Solvay Dustless Dense Soda Ash can be confidently relied upon in blast furnace operation:

1. for control of sulfur outside the furnace.
2. for routine control of sulfur resulting from adjusted slag practice to produce greater tonnage.

Write for full particulars today concerning the use of Solvay Dustless Dense Soda Ash for desulfurization. Write to

60th ANNIVERSARY 1881 · 1941

SOLVAY SALES CORPORATION

Alkalies and Chemical Products Manufactured by The Solvay Process Company

40 RECTOR STREET **NEW YORK, N. Y.**

BRANCH SALES OFFICES:

Boston	Chicago	Cleveland	New Orleans	Philadelphia	St. Louis
Charlotte	Cincinnati	Detroit	New York	Pittsburgh	Syracuse

Plants Located At: Syracuse, N. Y. • Detroit, Mich. • Baton Rouge, La. • Hopewell, Va.

weakly etched seem to give the best results. The current efficiency can under the best conditions be as high as 50-70%. The current density can be as high as 40 amp./dm.^{2}, even at high temperatures (140° F.). Ha (1b)

Equipment for Melting Aluminum

"Plant for the Melting of Aluminium and Its Alloys." *Foundry Trade J.*, Vol. 64, May 1, 1941, pp. 297-298. Descriptive.

Melting furnaces for aluminum and its alloys range in size from those with an aluminum capacity of 50 lbs. or less, up to equipment capable of melting 20 tons or more. For charges up to ½ ton, crucible furnaces are most conveniently used, while for those above 2000 lbs. reverberatory furnaces are more satisfactory.

Aluminum and its alloys are, in the molten state, powerful reducing agents, and, in the presence of silica and iron oxide, may abstract oxygen from these compounds. For hearth-type furnaces, sillimanite or high-grade fire-clay are satisfactory refractories for use in contact with the molten metal. For crucibles, kaolin-graphite or plumbago, silicon carbide, or close grained, well-annealed, gray iron are satisfactory.

The pressed-steel pot commonly used for melting magnesium-base alloy cannot safely be used for aluminum, which exerts a powerful solvent effect upon iron in this form. Some solvent action will occur with the cast iron, unless the inner surface of the pot be treated with a protective wash (a 50% kaolin suspension in water, containing about 5% of water glass as a binder, is widely used) which must be applied to the cleaned surface daily.

Irrespective of furnace design, and of the alloys being melted, certain conditions must be satisfied. To avoid gas contamination of the charge, the whole furnace structure, including crucible and lining, should be thoroughly dried out before production melting starts, by running without a charge or with light pilot charges; this operation may take from a few hours to one or more days. This "curing" procedure is of the utmost importance and, with some system of accurate temperature control, must be followed for every type and size of melting furnace, no matter what fuel or heating system be used.

Oil-fuel furnaces require careful regulation of the oil-air ratio to ensure perfect combustion, whilst the coke used for coke-fired plant should be stored in perfectly dry bunkers. AIK (1b)

Magnesium Alloys

"The Production of Magnesium Alloys." F. A. Fox. *Metal Industry*, Vol. 58, June 27, 1941, pp. 547-550. Descriptive survey.

There are 2 general methods for the production of magnesium: (1) The electrolysis of fused magnesium compounds, usually chlorides; (2) a thermic process of direct reduction of the oxide or carbonate. Most of the processes falling into these 2 general categories are based on the utilization of some form of magnesium oxide that may be derived either from magnesite or dolomite.

Magnesite is the principal raw material and should contain not less than about 93% $MgCO_3$. It is usually calcined.

The most satisfactory way of using dolomite is to remove the lime. This may be done by various means, chief among which is to decompose the calcined dolomite with magnesium chloride solution.

The process that was developed in Germany, and which has since been used most widely in England, was based on the chlorination of magnesium oxide by chlorine in the presence of carbon.

The chlorination of magnesium oxide is carried out in a vertical furnace charged with calcined magnesite and carbonaceous material. A stream of chlorine passes up the shaft of the furnace and reacts with the carbon and magnesium oxide.

Electrolysis of the fused anhydrous magnesium takes place in special cells, which are designed to enable the chlorine to be drawn off from the anode chambers. The cell is run at a temperature above the melting point of magnesium. The molten metal collects on the surface of the electrolyte at the cathode and is removed by hand ladles.

The metal produced is about 99.85% pure. Fluxing processes are employed to convert this material into satsfactory ingots for production.

The metal is melted in large cast steel crucibles where the alloying additions are made. The charge is then refined with a refining flux. The metal is superheated under a cover of this flux, the temperature not exceeding 1475° F.

After the superheating cycle has been completed, the charge is cooled rapidly to the casting temperature of 1330°-1380° F. and then poured into continuous ingotting machines.

The superheating process has pronounced effect in refining the grain, consequently improving the tensile, proof and elongation values of the cast material. (1b)

Processing and Fabrication 2

FORGING, FORMING, MACHINING
HEAT TREATMENT, WELDING, FINISHING

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting, Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

Grinding of Castings

"FETTLING ANALYSED." CARL A. CARLSON. *Foundry Trade J.*, Vol. 64, June 12, 1941, p. 391. Practical review.

Castings are submitted to grinding operations to obtain exact dimensions and a well-finished appearance, and such grinding operations are called "snagging." Of the many kinds of grinding machines used, the most common are floor stands and bench stands.

Heavy, well-guarded, 30 in. and 24 in. floor stands are used for production grinding on both light and medium sized castings. Swing frame machines are used when grinding large castings and also smaller ones when there is a considerable amount of material to be removed. Portable grinders are used for smoothing rough surfaces and to remove small defects.

High-speed wheels have proved successful for practically all steel castings when there are large shrink heads to be ground. The cutting grains in high-speed Bakelite-bonded grinding wheels (9,500 s.f.p.m.) are subject to a greater shock than in vitrified wheels running at 6,000 s.f.p.m.

For soft and tough castings and nonferrous metals the grains are hard enough to stay sharp. On hard castings with sharp fins or sandy surfaces the grains dull more quickly and added pressure will be necessary to make them cut.

More speed usually makes the wheels cut faster but on certain materials the abrasive grains will soon dull or fracture. Some kinds of castings and grinding methods require the wheels to withstand great pressure or shock and the softer Bakelite bond may not be strong enough to hold the grains; in such cases the harder vitrified bond is needed. Manganese steel castings are successfully ground with both high-speed and vitrified wheels.

Small malleable castings such as fittings can generally be ground cheaper with high-speed wheels. As high speed causes more grinding heat, there is a chance that some hard malleable castings may develop grinding cracks. In such cases the "Crystolon" [silicon carbide] type of vitrified wheels operating at lower speeds are preferable.

Gray iron castings are usually ground with No. 37 Crystolon vitrified wheels. Special grades of cast iron, such as are used in cylinder blocks for automobiles, are economically ground with high-speed Bakelite wheels. AIK (2)

Pre-Cleaning of Metals

"HOW TO PRE-CLEAN METALS." R. W. MITCHELL (Magnus Chemical Co.) *Iron Age*, Vol. 147, May 22, 1941, pp. 52-55. Practical

The pre-cleaning operation is the removal of grease, oil, smut, pigments and abrasives, or polishing agents such as emery, lithopone, lime, crocus, rouge, etc. The chief function of specialized pre-cleaning with alkaline cleaners is rapid penetration to the metal surface so as to loosen the dirt particle and render it capable of being flushed or rinsed off with the regular cleaning solution.

Factors to be considered are the effect of cleaner on the metal and the pH of solution; the latter should not be so high as to tarnish and discolor the surface. Another factor is the rinsing quality of the cleaner.

A satisfactory solution of the pre-cleaning problem is the emulsifiable solvent method. This method depends on the use of an emulsifiable solvent readily miscible with oils, which not only degreases the work, but penetrates and wets the solid particles to such an extent that they are completely loosened.

These solvents are supplied in the form of concentrates, to be mixed with safety solvent to make up the solution. The work is immersed at room temperature, usually for not more than 5 min. It is then pressure-spray-rinsed with cold water. The solution may be warm, but not over 140° F.

Further cleaning is needed for plating or similar finishing operations. A hot water rinse is used where it is desired to have the work dry off rapidly. Pre-cleaning is important where high current density and anodic cleaning methods are used.

The emulsifiable solvent cleaning solution has a long service life since it can stand considerable contamination without affecting its qualities. Work can be economically cleaned by this method if it does not have too many wells or pockets, which interfere with speedy and complete drainage. VSP (2)

Behavior of Refractories

"REFRACTORIES—SOME NOTES ON THEIR CONSTITUTION AND REACTIONS." J. F. HYSLOP. *Foundry Trade J.*, Vol. 64, June 19, 1941, pp. 409-410. Review.

Oxides are the chief components of igneous rocks, slags, and refractories, and they may conveniently be classified according to their mineralogical associations and increasing electropositive character. From this one gets 5 groups: (a) SiO_2; (b) Cr_2O_3, Al_2O_3, Fe_2O_3; (c) MgO, FeO, MnO; (d) CaO, SrO, BaO; (e) Na_2O, K_2O.

Beginning with silica, the most acid oxide, this order of increasing basicity corresponds with general chemical properties. First, the valency decreases from 4 to 1, and second, as estimated by X-ray crystal analysis, the metal ionic radii progressively increase.

That is, the acid oxides are characterized by having metal ions (charged atoms) of high valency and low volume, and the basic oxides by having ions of low valency and large volume. The metal ions, if they have the same valency and if they are about the same size, are interchangeable. For example, there are the well-known association of Mg'' and Fe'' and of Al''' and Fe'''.

The further the oxides are apart in the basicity series the more chance there is of the formation of a new mineral with distinctive characteristics. For example, experience confirms the ease of formation of

alkali and lime silicates, and of alkali and lime alumino-silicates.

Another point of considerable importance is that the more basic oxide tends to displace the less basic one. Thus, the addition of lime to magnesium silicate displaces the magnesia, and calcium silicate and periclase (crystalline magnesia) are formed.

And lastly, between ions of the same group, or those of adjacent groups, there is the tendency for ionic diffusion to take place with the consequent formation of solid solutions. In silica refractories the effective bonding medium is normally Ca'' with some Al'''' and Fe'''. One valuable feature of silica is the nature of its reaction with iron oxide. In reducing conditions Fe'' forms fayalite (2 FeO. SiO_2; M.P. 2200°F.) but in normal oxidizing conditions the fayalite decomposes, giving free silica plus iron oxide.

For some years now composite refractories made of chrome ore and magnesite have been developed. The experimental data show that the metal ions in chrome ore are loosely held and can travel easily into any medium that allows them to do so. The principal source of failure in chrome-magnesite refractories has been their troublesome reaction with iron slag.

The primary constituent of all magnesite bricks is crystalline magnesia-periclase. Periclase itself has desirable properties, such as high melting point (5000°F.) low solubility in lime and alkali slags, and high capacity for holding iron in solid solution. The periclase plus calcium silicate combination shows good resistance to attack by lime and high lime slags, but it is rapidly destroyed by magnetite and by slags high in acid oxides. AIK (2)

Still Tank Pickling

"A Brief Discussion of Still Tank Pickling." James P. ApRoberts (Lockheed Aircraft Corp.) *Monthly Rev. Am. Electroplaters' Soc.*, Vol. 28, Apr. 1941, pp. 271-278. Practical.

Formulas of typical pickling baths for brass are given. Of these, the bichromate pickle is not suitable for use prior to nickel plating because it causes poor adherence. This difficulty is overcome by following the pickle with a cyanide dip.

The author discusses the use of sulphuric-hydrofluoric acid mixtures for pickling iron castings and the use of ferric sulphate-hydrofluoric acid mixtures for stainless steel. The use of promoters such as arsenic or mercury, which are employed to hasten the action of acid is being discouraged because it also increases the hydrogen embrittlement of the steel.

The importance of inhibitors is emphasized. Specifications for a satisfactory inhibitor require that it be non-staining and free rinsing, creating no tarry or oily film in the bath. It must be non-foaming and give rise to no toxic fumes in the pickling tank, such as hydrocyanic acid, phosphine or arsine. The effectiveness of an inhibitor may be determined by comparison with a standard inhibitor, such as diorthotolylthiourea. AB (2)

2a. Ferrous

Furnace Atmospheres

"Carburizing and Decarburizing." F. A. Locke. *Iron Age*, Vol. 147, June 12, 1941, pp. 41-44. Practical review.

Surface carburization and decarburization of steels at elevated temperatures depend on several factors. In general, carbon monoxide and methane produce carburization, and oxygen, hydrogen (moist), water and carbon dioxide produce decarburization. Hydrogen and carbon monoxide should be in amounts 10 times as large as those of water vapor and carbon dioxide, respectively, in order for the steel to be safe from decarburization by the last two.

It is possible to attack carbide without affecting the iron of steel and also to decarburize without scaling. Thus, in open-firing it is better to have an oxidizing flame and allow scaling to absorb the decarburizing areas.

The use of dissociated ammonia requires a liquid-sealed retort and complete dryness of gas. The use of partially combusted gases permits a less efficient seal and retort than required with dissociated ammonia. However, this kind of gas can produce carburization and decarburization in many steels at certain temperatures.

Pure nitrogen, if used, must be employed in large quantities as it can overcome oxygen only by a mechanical flushing action. The other alternative is to purge the nitrogen with some other gas which is less expensive and more active. VSP (2a)

Heat Treating Stainless

"Heat Treatment of Stainless Steel." G. B. Berlien. *Steel*, Vol. 109, Aug. 4, 1941, pp. 74-76. Practical.

Heat treatment is an important factor in fitting stainless steel for use. Higher carbon stainless steels must be hardened for maximum physical properties and low-carbon, high-chromium, nickel steels must be annealed for working to obtain maximum stainless properties.

In hardening stainless steel, the practice of preheating is important. Large sections should have a first preheat of about 1000° F., allowing ample time for soaking, followed by a raise in temperature to 1450°-1525° F.

Small sections started at 1450° F. should be held at heat for from 2 to 10 times as long as one would heat a piece of tool steel at this temperature. Preheats of 4-5 hrs. are sometimes used where a maximum impact hardness combination is desired.

Transferring to the hardening temperature in another furnace is preferable. The furnace atmosphere, for best results, should be reducing. Hardening temperatures range from 1800° F. for 0.12% C(I.S.I. 403, 410 and 416) to 1925° and 1950° F. for 1.10% C(I.S.I. 440).

Oil quenching is recommended for hardening all carbon ranges, while air cooling can be used where difficult sections or warpage require it.

Parts of 0.12% C type can be straightened cold; parts of higher carbon ranges can be removed from the quench at 400°-500° F. and straightened by press.

Stainless steels should always be tempered after hardening. The low carbon ranges show little loss in hardness up to 700° F., but a draw of 300° F. for 3-6 hrs. is usually used. As the drawing temperature is raised on higher carbon ranges, the hardness drops. The range of 800°-900° F. is most always avoided as being a brittle range. [*It should be pointed out that the chromium steels are referred to above, and* not *stainless steels in general.*]

All stainless that can be hardened by heat treatment has decided air-hardening properties. Parts that have been forged should always be annealed or normalized. The annealing of the hardenable varieties of stainless may be carried out by slow heating to 1550° F. in a non-carburizing pack and cooled in the pot after the normalizing operation.

DISSTON

famous maker of saws, cuts costs 25% with a

PENNSALT CLEANER

By changing to a Pennsalt Cleaner about two years ago, Henry Disston & Sons, Inc., leading manufacturer of saws and other tools, achieved remarkable savings.

The cleaner is used to remove cutting oils from brass fittings for the handles of Disston saws before polishing the brass or nickel-plating. With this Pennsalt Cleaner, Disston saves three ways:

1. **Initial cost of cleaner is about 25% lower.**
2. **Less cleaner is required to handle the same volume of cleaning.**
3. **Labor costs have been reduced. With the previous cleaner, Disston had to use steel balls in the tumbling operation and then sort out the balls from the brass pieces after cleaning. With the Pennsalt Cleaner, no steel balls need be used . . . sorting is eliminated.**

Since cleaning requirements vary from one plant to another, we have many Pennsalt Cleaners . . . each with proved power to make metals "come clean" quickly and economically.

Have you checked your metal cleaning operations lately? If not, we would be glad to have your permission for our serviceman to call on you. If he can't serve you, he will frankly tell you so. Write today to Department G, Pennsalt Cleaner Division, Pennsylvania Salt Manufacturing Co., Widener Bldg., Philadelphia, Pa. Stocks of Pennsalt Cleaners in Boston, Chicago, Hartford, Philadelphia, Pittsburgh, Providence, Springfield, Mass., St. Louis, Wyandotte and Tacoma.

Brass saw fittings cleaned at a saving of 25% with a Pennsalt Cleaner.

REG. U.S. PAT. OFF.

PENNSYLVANIA SALT MANUFACTURING COMPANY

Chemicals

The 18-8 group of stainless have cold work hardening properties, and annealing here means restoring a solid solution of carbides in the matrix. A rapid quench from 1850° F. is required. Water is used whenever the danger of warpage is slight, and oil is used when the section is fairly light. (2a)

Best Structures for Machining

"Relation Between Microstructure and Machinability." Norman E. Woldman (Eclipse Aviation Div.) *Iron Age,* Vol. 147, June 19, 1941, pp. 37-40; June 26, 1941, pp. 44-49. Investigation.

In the manufacture of small aircraft gearing, the machining operations consist of automatic machining; drilling, forming counterboring, reaming, cutting off; broaching; roughing and finishing; turning; gear cutting; and roughing and finishing. Each operation requires a specially designed tool made from the required alloy and heat treated to a definite hardness.

The steels used for highly stressed aircraft gearing are usually oil-hardened types, such as S.A.E. 6150, 3250 and 4350. The steel that machined best in the automatics had a coarse spheroidized structure, while the steel most difficult to machine had a laminated-pearlite structure. A close-grained spheroidized structure dulled the tools more readily and developed more heat during machining than the coarse open-grained structure.

To determine the best microstructure to use communications were sent to various chief metallurgists. The replies verified the author's opinion that each shop must solve its own problems.

One reply stated that the best results for machining S.A.E. 3250 steel were obtained by quenching and tempering, another by continuous annealing at 1600°-1650° F. with slow cooling, another by normalizing from 1600°-1650° F. (air cooled), followed by immediate tempering at 1200°-1250° F., still another by heating to 1600°-1650° F. cooling slowly to 800° F. and finish cooling in air. One reply recommends furnace cooling from 1550° F. to 187 to 207 Brinell, and another advocated furnace cooling from 1450° F.

Machinability generally includes a concept of tool life and satisfactory finish. The following factors affect machinability: (1) the tool used; (2) the material cut; (3) the cutting oil; and (4) the operating machine. The main factors associated with machinability seem to be low ductility and strength.

When cutting with carbon tool steels, the failure is usually caused by wear on the flank of the tool directly beneath the active cutting edge. With high speed steels, normal tool failure is caused by a gradual cupping of the tool on its face. In turning steel chips are blue and purple in color at proper cutting.

To establish the relationship between microstructure and machinability of oil hardening steels, 9 bars of electric furnace steel measuring 1¾ in. were used. Three bars were of S.A.E. 3250, three of S.A.E. 4350, and three of 6150 steel. All bars were heat treated. Each bar was micro-examined for character and type structure, and machined for 1 hr.

These experiments showed that for S.A.E. 3250 and 4350 steels, the quenched-and tempered fine-grained spheroidized structure is the best for automatic machining. For S.A.E. 6150 a coarse-grained spheroidized structure is best for automatic machining. For all 3 steels, laminated-pearlite is best for broaching, for gear-cutting and for single point tool turning of bevel faces of gears. The spheroidized structure, obtained by long annealing at lower critical temperature is best for minimum distortion; the annealed laminated-pearlite produced most distortion.

VSP (2a)

Gas Defects in Enameled Iron

"Formation of Blisters, Pinholes and Black Specks on Vitreous Enamelled Cast Iron." A. L. Norbury. *Foundry Trade J.,* Vol. 64, Mar. 6, 1941, pp. 161-164. Review and research.

Three sources of gas bubbles during the enameling of cast iron are considered: (1) The gas may be formed from a reaction between an oxide defect and carbon in the metal, with the formation of CO_2 and CO. (2) The gas may result from a reaction between graphite or carbide in the metal and oxide in the enamel, again with the formation of CO and CO_2. Certain enamel constituents such as tin oxide, which is reduced to metallic tin, react rapidly, while others, such as silica, are, of course, not reactive at the enameling temperature. (3) A third type of gas bubbling arises from the liberation of gases that have been entrapped in the solid metal during solidification.

That graphite reacts vigorously with enamel, giving off gas, is shown by pushing a graphite rod into molten enamel. The reaction is very vigorous, but ceases rapidly owing to the inability of the enamel and the graphite to diffuse into one another.

According to the author, gas formed from this reaction in the wet enameling process forms defects only if the graphite size is large. Apparently—the author assumes—the gas bubbles formed by the small graphite flakes were too small to coalesce, while those formed by the larger flakes were able to do so and produce sufficiently large bubbles to produce visible blisters.

The boiling on the coarser parts of cast iron plate was considerable if they were shot-blasted before enameling, but was almost absent if they were emery-papered before enameling. Other conditions being equal, the boiling was less if the section was annealed before enameling, presumably owing to graphite being burnt away during annealing.

The author's explanation of the shot-blasting differences appears to be that shot-blasting burnished the surface graphite and delayed its reaction with the enamel until the latter had fused, after which the attack of the molten enamel on the surface of the metal and the annealing effect of the enameling temperature each had the effect of uncovering the graphite flakes and allowing them to react with the enamel, and produced gas at a later stage in the enameling operation.

Another effect of coarse graphite is that it tends to produce a higher combined carbon in the iron than is produced when the graphite is fine. Combined carbon in cast iron reacts with the enamel in a similar way to graphite, but if not present in too large amounts, may not cause sufficient gas evolution to produce defects.

The presence of combined carbon is, however, undesirable, since it is a potential source of gas evolution. If the combined carbon is considerable in amount, due for example, to the manganese content being insufficient to neutralize the sulphur present, the resulting high combined carbon will probably produce boiling all over.

[In general, this paper confirms the working hypothesis advanced in the paper "Blistering Phenomena in the Enameling of Cast Iron" by A. I. Krynitsky & W. N. Harrison, BUR. STANDARDS J. RESEARCH, *Vol. 4, June 1930, pp. 757-807—namely, that the carbon in some one or more of the possible forms (ordinary graphite, submicroscopic graphite, temper carbon or combined carbon) plays a major role in the formation of blisters. However, the data obtained in the Bureau investigation, referred to above, indicated that the massive graphite in itself can not be considered as invariably producing blisters. It was there shown that the large graphite flakes may extend to the surface of the metal without causing blisters. Such flakes may cause local poor adherence of the enamel, but poor adherence didn't seem to be necessarily connected with blisters.—* A.I.K.] AIK (2a)

The Witter Process for Shells

"SHELL PRODUCTION BY THE WITTER PROCESS." SAM F. KEENER (Salem Eng. Co.) & T. C. CAMPBELL (Staff) *Iron Age,* Vol. 148, July 3, 1941, pp. 51-53. Descriptive

The Witter process operates as follows: The billet steel is upset, forged or pressed to form a pierced blank. The blank enters the breakdown pass of humped rolls with a smoothly machined mandrel inserted in the cavity of the pierced blank.

The mandrel is kept bottomed in the blank by pressure from the pushing cylinder during breakdown, elongation and cross rolling operations. On elongation, the metal wraps tightly on the mandrel as it passes through the humped rolls, producing a smooth and uniform cavity in the shell forging.

The forging is sized with the mandrel still inserted and then the mandrel is automatically stripped, leaving the shell completed and ready for machining. Ten or more mandrels are continuously in use and are automatically cooled.

The hourly rate of production is about 280 75-mm. shell forgings. On 105-mm. shells, the hourly production is about 287 pieces. Using the complete process as developed by Salem Engineering Co., the estimated cost of forgings produced on the basis of 250/hr. is $39.50/1000.

An outstanding feature of the process is the saving of material by producing a 75-mm. shell from about 16 lbs. of billet steel, as against 20 lbs. used by some processes. The machined forging weighs about 10 lbs. VSP (2a)

Heat Treatment of Aircraft Gears

"HEAT TREATING AIRCRAFT GEARS." JOHN L. BUEHLER. *Iron Age,* Vol. 147, June 26, 1941, pp. 39-42. Practical review.

Almost all aircraft engine gears must be hardened without producing pits, scale, decarburizaton or serious distortion. Only the most accurate heat treating equipment is suitable.

Heating rates must be carefully controlled. As steel heats it expands to the Ac_1 line in the iron carbide diagram; it contracts on further heating until Ac_3 line is reached; more heating produces expansion. Therefore, a piece with appreciable variation in section thickness that is heated too rapidly will be stressed severely and distorted due to non-uniform heating.

To avoid distortion, the heating must be slow and uniform. The heat should be cut off at the transformation stage. Some distortion occurs in parts during quenching. This can be greatly mitigated by quenching on a falling heat.

As steel transforms from the annealed pearlitic condition through austenite to the final martensite, the volumetric change that occurs is in part dependent upon quenching temperature. Since most alloys grow when quenched from a high temperature and shrink a little when quenched near the recalescent point, volumetric change can be averted by varying the quenching temperature.

Smoothness in gear teeth is often of more concern than accuracy. Spurs or helicals that cannot be ground practically are made of oil-hardening steel and treated to 50-52 Rockwell C, using a long tempering cycle, producing sorbitic precipitation at the grain boundaries. These gears can be shaved.

Heat treatment of carburizing steel for maximum machinability involves quenching in oil after an hr.'s soak around 1500° F., and tempering at from 800° to 1200° F., depending on analysis of the material. This gives finely spheroidized sorbite.

Only gas carburizing has proved satisfactory, since only by this method can the carbon content or depth of case be predicted. Between 0.70 and 0.90% C content is the best.

The production carburizing must be done under laboratory conditions. At the moment the carburizing temperature is reached for a given steel, a predetermined atmosphere is applied.

Test coupons are removed at the end of the carburization period and immediately examined for case depth and carbon content. From this examinaton the atmosphere is regulated in the furnace to obtain the desired results.

To prevent paper scale, forming and discoloration during transference between the furnace and oil quench tank, shielding is necessary. The quenching oil stould be kept above 100° F. Under no circumstances should delicate parts be quenched. A cooling pit should be used. (2a)

Heat Treatment of Cast Iron

"Heat Treatment of Cast Iron." Charles A. Nagler & Ralph L. Dowdell. *Am. Foundrymen's Assoc.*, Preprint No. 41-5, May 1941. Investigation.

Two types of heat treatment were studied, (a) quenching-and-tempering, and (b) isothermal transformation by quenching in a salt bath at elevated temperatures. The irons were cast into 1.2-in. diam. test bars, which were machined to 1.0 in. diam. and then cut to 1.0-in. lengths. The test bars were polished to secure a smooth surface and a high rate of thermal conductivity.

The isothermally transformed samples were heated to 1600°F. and quenched in a salt bath at the desired transformation temperature. The quenched-and-tempered samples were held at the same temperature and quenched into water at 60°F. They were then dried and placed in a salt bath for tempering at the proper temperature and then quenched in water at 60°F. Both the quench-and-temper treatment and the isothermal transformation treatment were carried out over a wide range of temperatures.

The authors conclude that the hardness curves for both irons when isothermally transformed are parallel over a temperature range of 200°-1300°F. The same holds for the 2 irons over the same range when subjected to the quenching and tempering treatment.

The addition of molybdenum delays the rate of austenite transformation and increases the hardness of the samples after 1 hr. of isothermal transformation. The hardness of both the base and alloyed irons is higher after the quenching-and-tempering treatment than after the isothermal transformation for the same period of time and the same temperature.

CMS (2a)

Fluxing of Welds

"The Fundamental Nature of Welding. Part V. The Physical Chemistry of the Arc-Welding Process." Donald E. Babcock. *Welding J., N. Y.*, Vol. 20, Apr. 1941, pp. 189s-197s. Research report.

The slags from 81 weld metal tests were collected, analyzed and related to the difference in the composition of the weld metal and that of the original core wire for a series of 6 different flux compositions and 12 different rods.

The sulphur content was the same in the weld metal as in the core wire and phosphorus increased in some cases, due to pick-up influenced by the flux coating. The silicon content varied from 0.08 to 0.317% which correlated indirectly with the oxide contents of the welds.

The reactions of manganese and silicon with FeO in molten iron are considered to be $Si + FeO \rightarrow SiO_2 + Fe$ and $Mn + FeO \rightarrow MnO + Fe$, which are reversible and controlled by equilibrium phenomena and the thermodynamics of the reactions involved. The highest oxide values for the molten iron were found in the presence of the lower silicon and these values agree in both the equilibrium data and in the experimental tests.

By the use of equilibrium constants plotted against 1/T for manganese, silicon and FeO in molten iron the temperature of the system slag-molten metal at which the equilibria were established was found to approximate 3450°F. The equilibrium constants of silicon-manganese-FeO reactions in weld metal were calculated for each rod and flux used and found to be fairly constant for all the fluxes.

The conclusions from the study are: (1) An equilibrium between the metal and flux was to all practical purposes established; (2) these chemical balances remain in the rapidly quenched metal of the weld in a state substantially unchanged from the condition of their existence at the high temperatures of their formation; (3) these equilibria from theoretical calculation must be established at molten metal and slag temperatures of the order of 3450°F.; and (4) the activities of the slag components in these cases were in almost direct relation to their mol fraction so far as could be determined by these methods, with the possible exception of the alumina-rich slags.

WB (2a)

2b. Non-Ferrous

Welding Magnesium Alloys

"Welding of Magnesium." H. O. Hoglund. *Am. Machinist,* Vol. 85, July 9, 1941, pp. 637-640. Practical.

The coefficient of expansion of magnesium is quite high; moreover its strength at temperatures just below its melting point is low. Therefore, these 2 factors must be taken into consideration in welding; cracking is minimized by proper welding practice, while correct design will allow the part to contract freely.

Magnesium is corroded by the welding flux, so inclusion of the flux in the weld must be avoided and the flux must be removed immediately after welding. Lap welds and other welds producing pockets to entrap the flux must be avoided in gas welding, where only butt welds are recommended. No flux is needed in electric resistance welding.

Although torch welded joints can be made in magnesium and magnesium alloy sheet, these materials cannot be welded to aluminum or other metals. Welding rod should be of the same composition as the parent metal (often strip cut from the sheet is used). Oxyacetylene is preferred to oxy-hydrogen, and a neutral flame should be used.

Most magnesium welding rod and materials are supplied with a yellowish dichromate coating which should be removed with a wire brush or steel wool before fluxing. The flux (supplied as a powder) should be freshly mixed with water each day to form a paste.

If heavy plate requiring several passes must be welded, it should be done in an atmosphere of carbon dioxide to avoid oxidation. If any part of the weld should start to burn when welding is done in air, the oxidized part must be completely scraped and filed out because the oxide may be a source of corrosion.

The flux can be removed after welding with a wire brush and hot water. If this is not possible, the welded parts should be placed in boiling water with 0.55% sodium dichromate for 2 hrs. All welded structures should also be given the regular dichromate treatment for protection against corrosion.

In aircraft use, "as-welded" joints are usually specified. However, if a dressed weld is desired, it may be produced by chipping or milling the bead followed by hammering. The flux should be removed before any mechanical work is done; also, some magnesium alloys work-harden rapidly and should not be hammered.

In resistance welding, electrodes of ordinary copper are unsatisfactory, as the high pressure required distorts the contacting surfaces. Special hard, high-conductivity copper-base alloys are used. The tips must be cleaned of magnesium pick up after 10-20 spot welds. The dichromate coating must also be removed for resistance welding and should be removed within 3-4 hrs. of the time of welding.

The correct welding conditions must be determined by trial. If a chisel is driven between the sheets and spots, a slug of metal will pull from one of the sheets at each spot weld; the appearance of this slug is an indication of the strength of the weld. Moreover, if a section is cut through the weld, dressed with a file, and etched in 10% acetic acid, the cast weld zone should not extend to the sheet surface.

JZB (2b)

Lead Welding Technique

"Lead Welding Technique in Building Construction." A. J. T. Eyles. *Sheet Metal Inds.,* Vol. 15, May 1941, pp. 649-651. Practical.

The earliest technique was that used by the Romans in producing lead pipe from cast sheet. The sheet was formed into a tube so that the two meeting edges formed a channel. After sand had been packed on the inside of the tube and the outside of the channel, molten lead was poured into the channel.

A later and less satisfactory method involved holding a hot iron bar between the edges to be joined and so fusing them together. The resultant joint was thinner than the rest of the article.

Soldered joints are not so good as welded joints because the solder may become porous and weak during the wiping operation and cracking may occur due to differential expansion. Lead welding, on the other hand, is ideally suited for all types of work.

Oxy-acetylene, oxy-coal-gas, oxy-hydrogen, air-acetylene, air-hydrogen and oxy-butane may be used, but oxy-acetylene is the fastest. Surfaces to be welded must be scrupulously clean; usually the edges are well scraped immediately prior to welding. Fluxes should not be used.

The best results are obtained with a slight excess of acetylene, although some welders prefer a neutral flame. The flame should be practically perpendicular to the surface of the lead so as to afford easier control of heating with consequent less possibility of excessive melting of the lead.

JZB (2b)

Design and Applications 3

METALS, ALLOYS, METAL FORMS
ENGINEERING DESIGN, METAL SELECTION

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

3a. Ferrous

Corrosion of Boiler Steels

"EMBRITTLEMENT AND INTERCRYSTALLINE CRACKING OF BOILER STEELS." J. W. DONALDSON. *Metal Treatment*, Vol. 7, Summer 1941, pp. 45-49. Survey.

The work done in the investigation of "caustic embrittlement" of boiler steels from 1917 to the present time is reviewed. Emphasis is placed on the recent studies of this subject in England.

Parr & Straub at the Univ. of Illinois published the first report on their work in 1917. The report of observations of failures in boiler steels showed the cracks to be intercrystalline and to occur in boiler plates of good quality as well as in inferior plates.

Sodium carbonate was invariably present, and sulphates either absent or only present in small quantity, in the water of boilers that failed. Cracking that was intercrystalline resulted only when the material was stressed beyond its yield point, and when the concentration of sodium hydroxide was in excess of 350 grams/1.

Since concentration of the sodium hydroxide used in the experiments was far in excess of anything produced in normal boiler practice, it was suggested that high concentrations of over 30% could be produced by leakage and seepage of boiler water between butt-straps and plates and between rivets and plates. Experiments performed showed this to be possible.

In Germany, the work of the American investigators was ignored for some time. They attempted to explain such failure as being due to the steel used. Cold working and aging of steel was held responsible, and steel specially resistant to corrosion under temperature and pressure was tried. The steel failed, however, in the same way as the steels tested by Parr & Straub.

Much investigation of failures in boiler plate has taken place in England. Desch offers certain practical conclusions, which show that Parr & Straub's original explanation of caustic cracking is approximately correct.

These conclusions are: (1) Intercrystalline cracking is always associated with high alkalinity of water; (2) the steel must be in a condition of stress, the elastic limit having been exceeded; (3) there must be concentration of the solution in capillary spaces; (4) a high temperature must be reached, the temperature, however, depending upon the solution.

Furthermore, (5) intercrystalline cracks may be due to penetration of hydrogen and formation of methane by its reaction with the carbide of the steel, or may be caused by leaving the carbide unchanged, the cracks being filled with black oxide; and (6) cracks caused by corrosion fatigue are transcrystalline. (3a)

Alloy Steel Castings

RECENT DEVELOPMENT OF THE ALLOY STEEL CASTING ("Die neuere Entwicklung des legierten Stahlformgusses") H. L. KORSCHAN. *Tech. Mitt. Krupp, Tech. Ber.*, Vol. 9, Apr. 1941, pp. 1-15. Survey.

In his survey of developments in alloy steel castings since 1930, the author distinguishes between "low-alloy" and "high-alloy" steel castings, the dividing line being taken at about 5% of an alloy constituent. In Germany, particularly, the trend has been to replace more expensive or strategic materials, or even to use non-alloy material where stress conditions permit.

In the low-alloy class, a steel with 0.05-0.08% C and 3.5-4.2% Si is employed for instrument magnets. A steel with 1.5% Si and a carbon content of 0.40-0.75% (according to the hardness desired) is used for large gears.

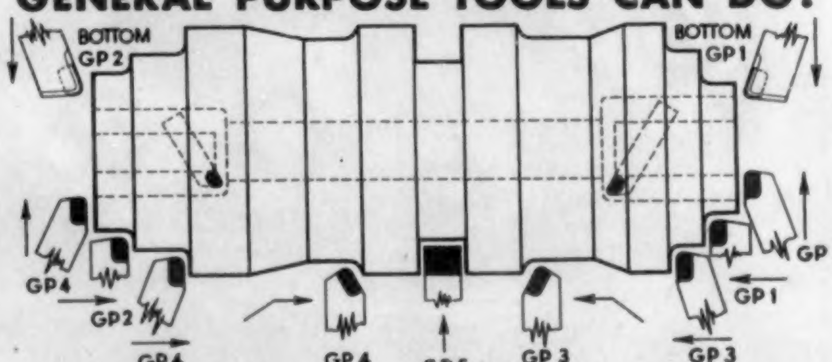
Manganese steels are now used to replace nickel and nickel-chromium steel castings, the composition being usually 0.20-0.45% C, 1.2-1.7% Mn and max. 0.4% Si. These steels have high tensile strength and elastic limit, while their elongation is only slightly less than in unalloyed steel. Hardened manganese steel castings showed on the average 72,000 lbs/in.^{2} elastic limit, 100,000 lbs./in.^{2} tensile strength, 55% reduction of area. For these tests, the steel was heated to 1500°-1600° F., quenched in oil, tempered at 970°-1200° F. and cooled in air or in the furnace.

Nickel steel with up to 5% Ni is in very many cases now replaced by unalloyed air-hardened steel castings of about 0.23% C, 0.43% Si, 0.60% Mn, which has an elastic limit of 39,000 lbs./in.^{2}, tensile strength of 65,400 lbs/in.^{2}, an elongation of 36.4%, and a reduction of area of 61%.

In special cases, where a very uniform hardness throughout is desired, a nickel steel casting with 0.26% C, 0.49% Si, 0.76% Mn and 2.83% Ni is used. When quenched at 1560° F. in oil, tempered at

FIRTHITE *GENERAL PURPOSE* TOOLS are *now* available *from stock* for *immediate shipment!* They are made in 5 carefully designed styles, 10 sizes, and 4 grades of Firthite Sintered Carbide tips . . . complete, ready-for-use, including ground-in chip breaking groove on tools for steel cutting. These tools are instantly applicable to fully 80% of the needs of the average shop. Further, they can be quickly modified, by simple grinding, for applications that require special shapes. Before ordering refer to your copy of FIRTHITE GENERAL PURPOSE TOOL List for styles, sizes, grades and prices, or write if you do not have one.

<u>SEE</u> WHAT FIRTHITE GENERAL PURPOSE TOOLS CAN DO!



The "theoretical" part shown above illustrates the broad adaptability of FIRTHITE GENERAL PURPOSE TOOLS. It shows a few of the many jobs that these standardized tools can do faster, better and cheaper.

FIRTH-STERLING STEEL COMPANY

OFFICE AND WORKS:
McKEESPORT, PA.
BRANCH WAREHOUSES:
NEW YORK CHICAGO
HARTFORD PHILADELPHIA
LOS ANGELES DAYTON
CLEVELAND DETROIT

1180°-1200° F., and cooled in air, it has 76,000 lbs./in.^{2} elastic limit, 98,000 lbs/in.^{2} tensile strength, 22.6% elongation and 63% reduction of area.

This material is used for autoclaves for the production of synthetic soap as it is caustic-resistant; otherwise, molybdenum or chromium-molybdenum steel is used. Other steels in this class are chromium-nickel steels for very highly stressed structural parts, molybdenum and molybdenum-chromium steels in the aircraft industries and for heat- and scale-resisting materials.

High-alloy steel castings are employed in cases where special mechanical, chemical and physical properties have to be met. The highly heat-resisting members of this class have a tendency to coarse grain formation. The design of the piece must avoid local concentration of stresses.

For a non-magnetic material that does not require machining, castings of 12% Mn steel are used; otherwise, a chromium-manganese steel with 18% Mn and 1% Cr is employed. Lately, permanent magnets have been made of steel with 27% Ni and 14% Al, which is extremely hard and brittle and can only be shaped by casting and machined by grinding. These steels are further improved in magnetic quality by additions of up to 25% Co.

Ha (3a)

The Stainless Steel Market

"STAINLESS STEEL—1940." T. W. LIPPERT. *Iron Age*, Vol. 148, July 17, 1941, pp. 39-47, 117-119. Survey.

All phases of stainless steel consumption for the year 1940 were probed and the conclusions arrived at were based on individual reports from 83.2% of the 4,960 consumers of stainless steel alloys.

The 18-8 analysis, as usual, was first, accounting for almost 50% of the 1940 consumption. Sixteen-18 straight chromium was second, and 12-14 straight chromium was third.

It was found that the average over-all conversion of the ingot output to the finished steel was about 61.4%. 1940 ingot production of all analyses was 264,875 net tons, which is at least 52% above the previous record year of 1939.

Stainless in strip form occupied the dominant position, 63,080 tons, accounting for over 38% of total consumption. The second major outlet was in bar and heavy rods, 35,176 tons, and in close third came sheets with 32,740 tons. Wire consumption rose to 14,495, and 6,796 tons of stainless steel went into tubular goods.

The consumption of stainless steel castings in 1940 was around 11,823 tons, 23% above the record year of 1939; 18-8 analysis retained its popularity.

A rough geographical breakdown was made of stainless steel consumption. The country was split into 4 sections. The Central States and the Northeastern States were found to be in the lead, accounting for 47.4% and 41.6% of the total, respectively. The South and Southwest consumed 1.6%; the far West used 5.9%; 3.5% was exported.

As concerned the application distribution, the automobile industry was the single best customer, using 35.3% of the total. Food handling accounted for 15.9%, and transportation, other than automobiles, needed 21.5%. Chemical equipment, machinery, household equipment, and building construction followed in that order.

Since defense effort has taken most of the producer's time, few new developments have come out the past year. However, there were a few trends that should be mentioned.

The scarcity of nickel has forced a number of producers to consider Type 431 steel, containing 16% Cr and 2% Ni. In 1940, about 1,455 tons were used. Straight chromium and chromium-nickel analyses, as well as those containing manganese, have been considered.

Of great value were the investigations to adapt stainless steel to aircraft construction. Other studies dealt with the investigation of various factors exerting their influence upon the processes of decomposition of austenite, and the part played by various elements found in stainless austenitic alloys.

The most significant development was success of the Pluramelt process, credited to R. K. Hopkins. Popular experimentation in stainless steel was that dealing with permanent coloring of the various alloys.

The 3 critical products in stainless steel manufacture are scrap, chromium and nickel. Very few sources of chrome have been cut off so far by the war, and it appears that doubling the stainless steel production next year will not be a too severe drain on the chrome supply.

Nickel is only available in defense industries. It is difficult to predict the supply available next year. Scrap is none too plentiful, but the situation at the moment is not particularly serious. (3a)

3b. Non-Ferrous

Aluminum Bronzes

"ALUMINUM BRONZE FILLS DESIGN NEED." J. D. ZAISER. *Machine Design*, Vol. 13, July 1941, pp. 49-51. Review.

Aluminum bronze is rapidly assuming an important position in the field of machine design. The characteristics common to this series of alloys that make it applicable are: uniformly good physical properties, controllable hardness range, good corrosion resistance, retention of physical properties at high temperatures, and high impact strength and high endurance limits.

The aluminum bronzes may be put in two general classifications: The low-iron type, containing less than 1.25% Fe as an alloy addition, and the high-iron type with 2.5-4% Fe. The latter type has smaller grain size, greater hardness and higher resistance to wear.

The aluminum content influences the properties considerably. Less than 9% results in a very ductile alloy, predominantly "alpha" crystals; 9.5-11.8% gives a much harder and brittle structure; over 11.8% gives a percentage of "delta" crystals and results in extreme brittleness. There are 3 general fields of service—notably bearings, gears and corrosive applications—for these alloys.

Aluminum bronzes containing over 10% Al are well adapted to bearing service. The structure of this alloy is composed of hard particles supported in a softer matrix. Included in the category of bearing applications are bushings, slides, gibs, and thrust bearings.

Aluminum bronze is best suited for comparatively slow speed applications, but it has been used satisfactorily for spindle bearings on precision grinders with a speed of 1200 ft. per min. High compressive strength and its high impact strength particularly suit it for heavy duty service. Among the applications here are: universal joint bearing segments between rolls and mill drives; track roller bushings and turntable roller bushings on earthmoving and construction equipment.

Widest users of aluminum bronzes for gears are heavy machinery builders and machine tool manufacturers, because of the

material's high physical properties in tension, shear and compression, its good wear resistance and proportional limit. Applications where aluminum bronzes have proved satisfactory are those in which the loading is extremely heavy, the installation subject to impact loading, and the operation intermittent.

The excellent corrosion resistance of aluminum bronze is due to the almost immediate formation of a film of aluminum oxide on the alloy's surface, whether cast or machined. The film, though thin, is closely adherent, has high resistance to attack by the majority of acids and some alkalies, but is not equally effective with all corrosive media.

The film is self-healing; when broken or removed, it immediately reforms. At present, the widest use of aluminum bronze is in pickling equipment installations and the petroleum refining industry.

In addition, there are a great many other types of service to which the aluminum bronzes are suited. They include the resistance welding field, high temperature service, and use for forming and drawing dies. (3b)

Aluminum-Magnesium Piston Alloys

THE USEFULNESS OF ALUMINUM-MAGNESIUM ALLOYS FOR MOTOR PISTONS ("Die Eignung von Werkstoffen auf Aluminium-Magnesium Basis für Motoren-Kolben") E. MEYER-RÄSSLER. *Metallwirtschaft*, Vol. 19, 1940, No. 33, pp. 713-721. Practical

Investigations aiming at the development of a wrought aluminum-magnesium alloy suitable for pistons and possessing high strength and hardness at elevated temperatures, together with favorable thermal conductivity, are reported.

Although a number of light alloys for piston application are available, none meets all requirements. To save weight by alloying aluminum with magnesium has been only partly successful as magnesium contents exceeding 12% render the alloy brittle, and additional alloying elements bring the aluminum-magnesium alloy into the "weight-class" of aluminum-silicon piston alloys.

Thermal expansion and thermal conductivity properties are not satisfactory yet but bending fatigue strength is good. The running properties could be further improved, but at the expense of strength.

The hardness and tensile strength of aluminum-magnesium alloys are inferior to age-hardened aluminum-silicon piston alloys at room temperatures and up to 400° F., but superior above the latter temperature. Further improvements should aim at a more favorable strength at elevated temperatures without impairing the other favorable physical properties already secured. EF (3b)

Industrial Applications of Silver

"AMERICAN SILVER PRODUCERS' RESEARCH PROJECT." Progress Report, issued by Handy & Harman, New York, July 1941.

The field of electroplated coatings continues to show promise as an outlet for silver and the Project's pilot plating plant has been kept busy recently plating drums, pails and cans. A large can manufacturer is cooperating with the Project and a chemical supply house in the development of a silver-lined can for packaging chemicals.

One of the criticisms of silver-lined containers appears to be that they do not give sufficiently superior advantages over those now in use to warrant the additional cost.

The Care and Feeding of... an IDEA

Powder metallurgy, in certain well-established applications, is far from a fledgling. But current explorations of the possibilities of powders and the uses of sintered powdered metal parts, are producing new ideas that deserve nourishment.

Potentially, powder metallurgy offers important economies and saving of time in the production of a vast number of parts used in industry. Its specific application to making a given machine part (or material for fabrication into a part) may today be just an idea. To foster the idea into practical realization is the responsibility of metallurgist, machine designer and *manufacturer of metal powders.* It is essential to design with the limitations as well as the possibilities of metal powder manufacture in mind. Powders must be manufactured to definite specifications based upon desired properties for the particular application.

We have been producing metal powders of all types for a quarter of a century. We have learned a good deal about what can be done with this special production technique. The experience of a considerable staff of metallurgists, chemists and engineers is at the disposal of manufacturers. We welcome requests for information.

METALS DISINTEGRATING COMPANY

ELIZABETH NEW JERSEY

PIONEERS IN METAL POWDERS
FOR A QUARTER CENTURY

For the general run of containers this at present is undoubtedly the case, but it is not true for packaging some specialized products. In some instances silver-lined containers are being seriously considered and tested for packaging corrosive materials because the corrosion resistance of other metals and lacquers is not adequate.

In recent months the scarcity of many base metals has focused attention on the use of silver as a substitute for aluminum, nickel and tin. In places where sheet or foil aluminum has been used, for its corrosion resistance or high reflectivity, it is apparent that silver plating on available metals can be substituted since it possesses these qualities, for most purposes, to an even better degree than aluminum.

Silver electrodeposits are being investigated as a substitute for nickel, as an undercoating for chromium plating. Advantages may be derived from the use of a corrosion resistant electroplate of silver followed by a hard, wear-resistant chromium deposit.

Experiments have been conducted to determine the strength of extruded tubing made from a 3.5% Ag, 96.5 Sn alloy. A bursting strength of 2,500 lbs./in.[2] or almost double that of pure tin, was obtained—far in excess of any working pressure encountered in distilled water lines where this material is finding commercial use.

Tests on threaded joints showed that the alloy had a tensile strength 25% greater than joints made with pure tin tubing. For certain installations, it would seem feasible to use threaded connections in distilled water lines if the tubing were made of the silver-tin alloy. Both the 3.5% Ag and 5% Ag tin alloys are finding applications as solders.

Interest continues in the possibilities of using lead-silver solders in place of the standard lead-tin alloys in automatic can-making machines, to save tin. The 2½% Ag lead alloy is actually cheaper than standard solder and the joints are equally satisfactory.

FPP (3b)

Zinc Alloys for High Temperatures

The Creep Strength of Zinc Alloys ("Dauerstandsfestigkeit von Zinklegierungen") Franz Pawlek & Max Pfender. *Z. Metallkunde*, Vol. 33, Feb. 1941, pp. 84-96. Extensive original research.

The high tensile strengths of commercial zinc alloys are not associated with correspondingly favorable creep strength values. The latter are surprisingly poor and quite unrelated to tensile strengths.

Creep curves of zinc alloys do not show the same course. They may intersect after about 50 hrs. The creep (at constant tensile load) after 150 hrs. offers a more reliable value. For large-scale sag tests, the authors preferred to bend-test wires clamped at one end without load on the free end.

The object of this investigation was to study the effect, on the creep strength of zinc, (a) alloy additions like aluminum, magnesium, copper and lithium, available in Germany, (b) the principal contaminations (such as lead and cadmium) in the commercially pure grades of zinc, and (c) supposedly extremely detrimental elements like iron, nickel and manganese. The alloys were hot-rolled and then cold-drawn 50%. Two further sets were studied in the annealed state, *i.e.* 2 hrs. at 300° F. and 2 hrs. at 575° F.

Besides creep strength, the following properties were determined: tensile strength, elongation and bending number. In general, the individual or combined alloy additions did not exceed 1%.

Among the commercial alloy additions, only copper increases the creep resistance. Magnesium, which raises the room-temperature tensile strength, does not affect the creep strength. Lead and cadmium exert only a small effect, cadmium obviously being responsible for the brittleness.

Contrary to prevalent ideas, elements of the iron group advantageously affect the physical properties, including creep strength. Ternary alloys of zinc with iron + manganese, iron + nickel and nickel + manganese are distinguished by extraordinarily high elongation values in the annealed state and very good creep resistance. The same holds for cold-worked zinc alloyed with copper and iron.

Adding aluminum in conjunction with metals of the iron group offers no advantage; likewise alloying the iron metals with commercial zinc alloys affects the creep strength but little. The favorable creep resistance of alloys of zinc with the elements of the iron groups is explained on the basis that these alloys are of the precipitation hardening type in spite of the small solubility of these metals in zinc. The usual alloy constituents in commercial zinc alloys seem to prevent supersaturation of the solid solution containing the iron group metals (see also Metals and Alloys, Vol. 13, May 1941, p. 644 which stated that magnesium improved the creep resistance of a zinc alloy with 4% Cu, 0.2% A.)

EF (3b)

Testing and Control

4

METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings, Surface Measurements. Metallographic Structure and Constitution.

Micro-Hardness Testing

A Composite

The Hanemann micro-hardness tester recently developed in Germany and manufactured by the Zeiss works aroused considerable interest both abroad and in this country. The tester and its possibilities have previously been described in METALS AND ALLOYS, July 1940, p. 108 and July 1941, p. 112. American engineers and metallurgists have been particularly attracted by its potentialities for the hardness testing of porous powder metallurgy products and of multi-phase alloys in general.

Two juxtaposed articles in a recent issue of a German magazine have examined the fundamentals of micro-hardness testing and presented an interpretation of phenomena observed. First, FRIEDRICH SCHULTZ & HEINRICH HANEMANN ("Die Bestimmung der Mikrohärte von Metallen," *Z. Metallkunde,* Vol. 33, Mar. 1941, pp. 124-134) deal with some fundamentals of hardness testing, study the dependence of micro-hardness on crystal orientation, propose a micro-hardness testing method and determine the micro-hardness of metallic compounds present in aluminum.

As the micro-hardness testing method normally tests individual crystals, the effect of anisotropy was investigated. Systematic tests on aluminum and antimony showed that the position of the testing surface relative to the axes of the crystal affects but little the micro-hardness.

The decrease of micro-hardness with increasing loads is largely attributable to work-hardening of the surface in grinding and polishing. In the case of electrolytic polishing only a very small decrease of hardness with rising loads remains—an effect also noticeable in macro-hardness testing.

When the load is plotted in relation to the diagonal of the indentation on a logarithmic scale, the micro- as well as the macro-hardness data fall on a straight line, the slope of which is tan $\alpha = 1.905$. With electrolytically polished surfaces, the micro-hardness of aluminum thus follows the Meyer equation $P = a \times d^n$ where $n = 2$, P = load, d = diam. or diagonal of indentation and a = a constant, characteristic of the material under test.

In spite of geometrically similar indenta-

First Choice

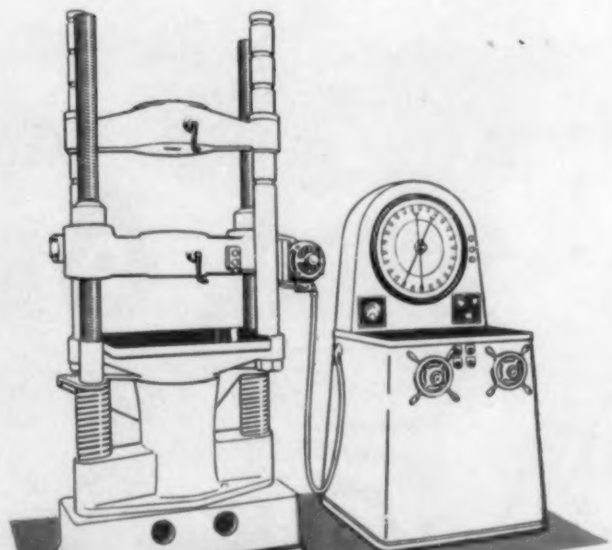
OF THE

AIRCRAFT INDUSTRY

BEECH ★ BELL ★ BENDIX ★ BREEZE ★ BREWSTER ★ CESSNA ★ CONSOLIDATED ★ CURTISS AEROPLANE ★ CURTISS PROPELLER ★ DOUGLAS ★ ECLIPSE ★ GRUMMAN ★ HAMILTON STANDARD ★ HAYES INDUSTRIES ★ HUGHES ★ MARTIN ★ NORTH AMERICAN ★ NORTHROP ★ REPUBLIC ★ SOLAR ★ SPERRY ★ STEARMAN ★ THOMPSON PRODUCTS ★ TRIPLETT & BARTON FOR LOCKHEED AND VEGA ★ VULTEE ★ WRIGHT AERONAUTICAL

In no other industry is testing more important; in no other industry is speed more essential. It is significant that these leading manufacturers have chosen Southwark-Tate-Emery Testing Machines.

Baldwin Southwark Division, The Baldwin Locomotive Works, Philadelphia; Pacific Coast Representative, The Pelton Water Wheel Company, San Francisco.



Baldwin Southwark

DIVISION OF THE BALDWIN LOCOMOTIVE WORKS

PHILADELPHIA

BLH THE BALDWIN GROUP

tions, Kick's law is not applicable to micro-hardness tests. It appears inadvisable to standardize on a constant load. With soft material, the crystal size would be too small and the indentations too large, while with hard crystals, the indentations would become immeasurably small.

To place the micro-hardness test on a scientific basis, it is suggested to standardize on a constant size of indentation. The latter can be obtained by graphical interpolation of impressions, some of which are larger and some smaller than the standard.

Many intermediary phases occurring in binary aluminum-alloys were tested with reference to different indentations: Al_3Mg_2 = 340, Al_3Ni = 770, Al_4Co = 735, Al_2Cu = 560, Al_3Fe = 960, Al_7Cr = 510, $Al_{11}Cr_2$ = 710, Al_6Mn = 540, Al_4Mn = 778, Al_2Ca = 208, Al_3V = 395, AlSb = 1480, Si = 1320. The comparatively high hardness of the last two materials is not surprising as they possess the diamond structure. With the exception of Al_4Mn, all crystal phases possess a constant micro-hardness over the wide testing range applied, *i.e.* $n = 2$.

In a second article, E. O. BERNHARDT ("Ueber die Mikrohärte der Feststoffe im Grenzbereich des Kick'schen Ahnlichkeitssatzes," *Ibid.*, Vol. 33, Mar. 1941, pp. 135-144) interprets the phenomena observed in the determination of micro-hardnesses of solids with the Hanemann-Zeiss tester.

The originally described model has been improved, and the resolving power has now been doubled. Kick's law, it is agreed, does not hold for micro-hardness testing. The micro-hardness depends not only on the physical properties of the tested material, but also on the size of indentation. This interrelation is covered by the Meyer rule, whose exponent "n" deviates more from 2, the less Kick's law is obeyed. The deforming force is only partly absorbed by the formation of the indentation.

This portion follows the Kick law and represents a function of the displaced volume. The balance of the deformation work is spent in the formation of "internal surfaces" and the region thus affected lies close to the surface.

Tests on glasses show that the Meyer rule still holds in spite of the absence of gliding planes. The brittleness of glasses can be determined by micro-hardness tests, which thus show a distinct connection with the internal stresses that can be computed on the basis of the previous history and of thermal data.

Testing results on graphite, aluminum, boron carbide, chlorides, fluorides, bromides and various glasses are presented in support of the author's deductions. EF (4)

Spectroscopy of Scrap Aluminum

SPECTRUM ANALYSIS OF REMELTING ALUMINUM ("Spektralanalyse von Umschmelz Aluminium") H. MORITZ. *Aluminium*, Vol. 23, Mar. 1941, pp. 136-140. Descriptive.

The research laboratory of the Aluminium Ind. A. G. in Switzerland reports success in the routine application of quantitative spectrochemical analysis to aluminum and its alloys.

Ordinary chemical analyses, in spite of extensive mechanization, require 2½ to 3 hrs. for 30-40 samples. By spectrochemical methods, however, 200 samples can be tested in 8 hrs. with a cost of about ¼ that for chemical analysis. Spectroscopic methods also permit the immediate detection of the undesirable or harmful impurities by their lines.

In a series of about 1400 iron determinations made by both methods, 78.4% of the spectro-analyses were in agreement with the chemical analysis; 17.4% of the chemical analysis were "wrong," but only 4.2% of the spectroscopic analyses were "wrong." Preparation of calibration electrodes for the spark, production of proper blackening of the lines on the photographs, and evaluation methods are described.
Ha (4)

Non-Destructive Seam-Detection

NON-DESTRUCTIVE DETECTION OF INTERNAL SEAMS IN SHEETS ("Zerstörungsfreie Feststellung von Dopplungen in Blechen") W. JELLINGHAUS & F. STÄBLEIN. *Tech. Mitt. Krupp, Forschungsber.*, Vol. 4, Apr. 1941, pp. 31-36. Descriptive.

A source of trouble in many steel sheets is the laminar separations in the material lying parallel to the surface. Such defects can be harmless under tensile stresses in the place of the sheet, but under bending stresses only part of the section takes the whole stress and the sheet may break.

The causes of such seams are hollow spaces or blisters in the ingot, which are squeezed together in rolling. An electrical apparatus is described which, when connected to the sheet, permits detection of the direction and extent of the defects by current and voltage measurements in various directions; the electric resistance across the section changes where seams occur. An example is given illustrating the procedure and evaluation of the measurements.
Ha (4)

books

Non-Ferrous Production Practice

NON-FERROUS PRODUCTION METALLURGY. *By John L. Bray. Published by John Wiley & Sons, Inc., New York, 1941. Cloth, 6 x 9 in., 430 pages. Price $4.00.*

Few books adapted to classroom instruction in non-ferrous metallurgy are available, and most of them are old. Accordingly this new book will be welcomed by many. The author has kept the size (and price) of the book within bounds for student use by confining it strictly to process metallurgy, and by omission of all photographs.

After the introduction, four short chapters are given on metals and ores, slags and fluxes, secondary metals, and marketing; the remaining 23 chapters take up the commercial non-ferrous metals in alphabetical order, each in a separate chapter. Rather than the alphabetical arrangement, many instructors would prefer a grouping of the metals according to the type of extraction process chiefly used for them, such as smelting, distillation, electrolysis of fused salts, reduction without fusion, etc.

The general criticism might be made that this work, intended like others on the subject as a "survey," is mainly descriptive, with insufficient consideration of reasons and little attempt to show correlation of principles and practice as most teachers desire to do. Admittedly a good solution of this problem is difficult, especially because of limitations of time and space, but it is to be regretted that this new book contributes little thereto.

Each chapter follows a uniform plan, beginning with a paragraph on the history of the metal, a brief discussion of economics and world production, a simple listing of ten principal properties, a paragraph on marketing and prices, one on uses, some sketchy information on the principal alloys and on ores, and a more extended description of the processes and furnaces or other principal equipment used in extraction and refining.

An excellent innovation is the use of simplified line drawings of apparatus which show the principal parts and dimensions with clarity. Numerous flow diagrams are also a valuable feature. In the object of bringing the material up to date, the author has succeeded well; exceptions may be noted under beryllium, bismuth, and refining of copper.

It is not to be expected that errors would not creep into a book covering so broad a field. The reviewer has noted a number, only a few of which need be mentioned. In listing the impurities in aluminum, iron is omitted and tellurium written for titanium. It should not be said that from the heat of a reaction the voltage is calculated by Faraday's law, nor is it true that low current densities produce fine-grained electrolytic deposits. Acid-lined copper converters are deader than one would suppose from the text, but hand-charging of horizontal zinc retorts has not been replaced by mechanical charging to the extent indicated.

The book on the whole is well balanced and complete within its intended scope. More space might well have been given to aluminum, but few things are omitted that one would expect to find. The volume will be useful to many.

—ALLISON BUTTS

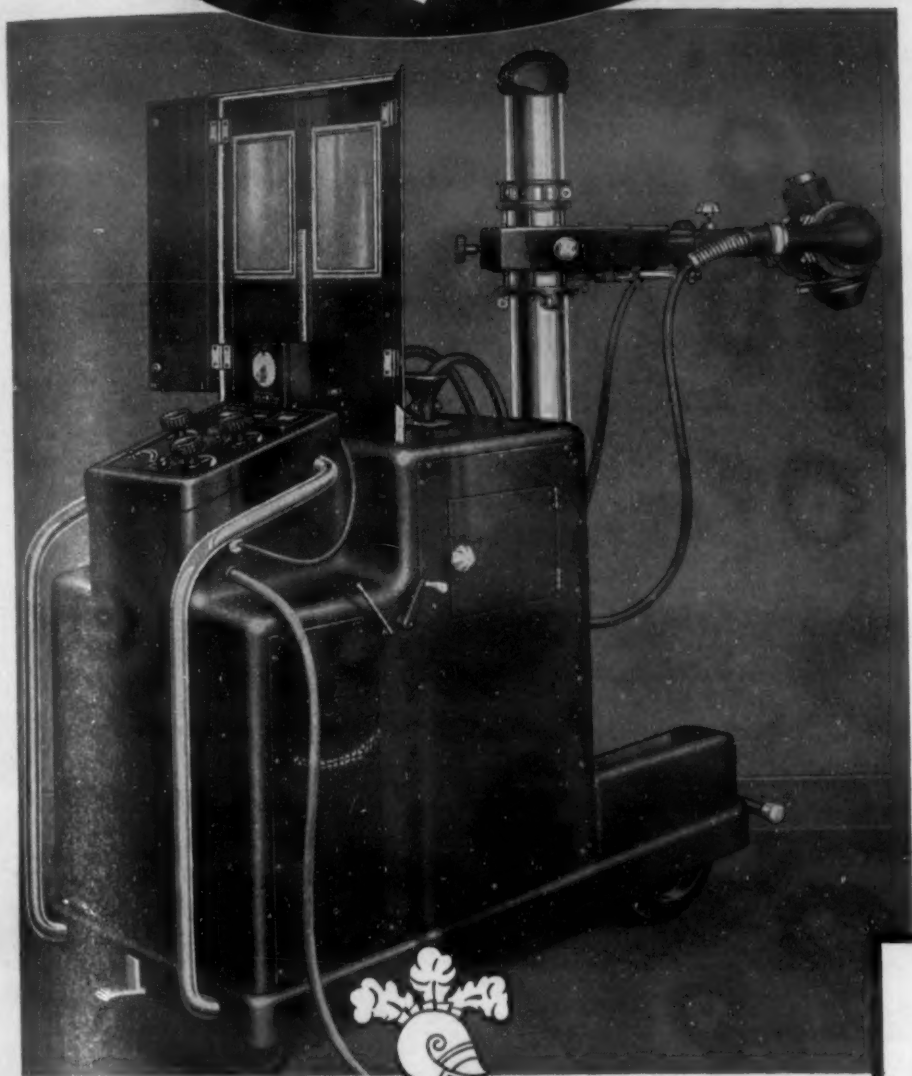
Non-Ferrous Foundry Practice

NON-FERROUS FOUNDRY PRACTICE. *By J. Laing & R. T. Rolfe. Published by Chapman & Hall, London, 1941. Cloth, 5½ x 8½ in., 336 pages. Price $4.00.*

The contents of this book appeared serially in the *Metal Industry*, London, the book itself appeared in 1940, and it has been reprinted in 1941, indicating a real call for the volume in England.

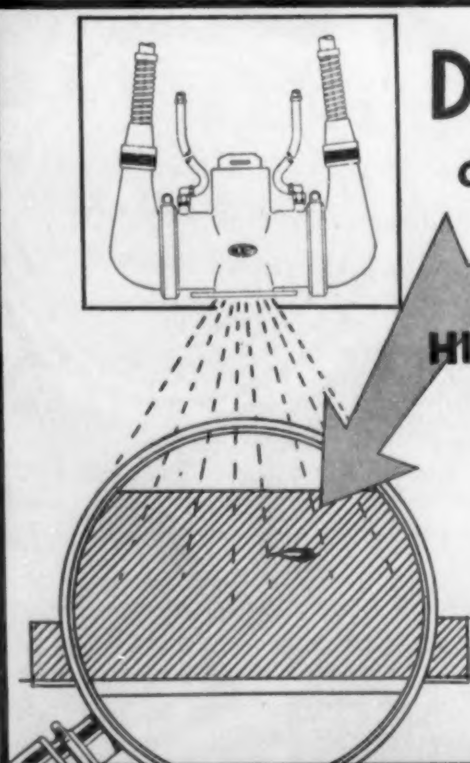
(Continued on page 390)

Inspection by X-RAY



THE increasingly stringent demands put upon industry—particularly in all branches of metal working—have made it almost mandatory that X-Ray be used for inspection and examination.

Proven in the field of Medicine and in the Metallurgical Laboratory, X-Ray inspection equipment is also invaluable for industrial use. Here X-Ray provides for accurate examination by disclosing hidden defects in castings of aluminum, steel, grey iron, malleable iron or bronze and by detecting small or major flaws in all welding procedure—all without interfering with the production line.



DETECTS as little as 2% HIDDEN FLAWS

Unit illustrated will penetrate 1½ inch steel —4 inch aluminum. Is self-contained— compact and portable. Will go through 30" door— can be taken on average factory elevator. Can be plugged into any 110 A C socket. No external water connections required.

KELEKET

INDUSTRIAL X-RAY EQUIPMENT

Industry—requisitioning the X-Ray for inspection—must decide which X-Ray equipment will be most profitable, most economical, and best adapted for each individual need. Here is where experience and reputation count. We are pioneer makers of X-Ray apparatus and have been specialists in it for 41 years. The making of X-Ray equipment is our sole business.

Because of this specialized experience we are equipped to meet the demands of industry and we have available various types and sizes applicable to the metal industry. Our engineers are at your service to advise you how a Keleket unit can solve your inspection problems—whether in the use of one of our regular, standard units or in creating and building a unit tailored to fit your specific needs. For further information, mail the coupon.

THE KELLEY-KOETT MFG. CO., COVINGTON, KENTUCKY

REPRESENTATIVES IN 64 CITIES

Pioneer Creators of Quality X-Ray Equipment Since 1900

The Kelley-Koett Mfg. Co.
220 West 4th St.,
Covington, Ky.

● Without obligation please advise me further how Keleket Equipment can be used profitably in this plant for inspection of.......................... *Title*..................

Name..........................

Firm Name..........................

Address.......................... *State*..................

City..........................

The main topics are: Bronzes; copper and brasses; high strength brasses; aluminum bronzes; silicon bronzes and brasses; cupro-nickels; aluminum alloys; magnesium alloys. The more important alloys in each class are described and for many, both the British and the A.S.T.M. specifications are shown.

Kinks for the molding, gating, melting and handling of each main type of alloy are separately discussed. It is this feature that gives the book its chief value, for the data on specifications and properties are elsewhere available, though perhaps not so conveniently arranged.

More could be said than is said here about some of the alloys, and not all of the important published information has been utilized, but in general, the information given is adequate.

—H. W. GILLETT

Metals as Commodities

COMMODITY YEAR BOOK—1941. *Published by Commodity Research Bureau, Inc., New York, 1941. Cloth, 8¾ x 12¾ in., 636 pages. Price $7.50.*

Statistics on production, imports, exports, and prices of selected commodities are prefaced by brief, rather non-technical discussions of uses, trade practices and the like. The metals dealt with are aluminum, copper, gold, iron and steel, lead, manganese, tin and zinc. Similar information on these is already accessible to most metallurgical engineers. However, when one wants similar information on wheat, beer, hay, glass, rosin, hogs, pepper, alcohol, eggs, paper, coal, oil, hides, rubber, silk, and a score of other things, he may not know where to find it and he probably needs just such a general, non-technical discussion of those industries as is given in this yearbook. It is a useful reference book.

—H. W. GILLETT

Aluminum Bronzes

THE PRACTICAL APPLICATION OF ALUMINUM BRONZE. *By C. H. Meigh. Published by McGraw-Hill Book Co., New York, 1941. Cloth, 7¼ x 10¾ in., 112 pages. Price $4.00.*

The author is director of an English firm producing aluminum bronze, who thinks that existing literature on the alloy has taken an academic form, so he sets out to write a book of his own. His thesis is that aluminum bronze is a swell material of engineering and that his firm knows just how to handle it.

The book is strong on evidence and argument that might lead a designer to use the alloy, very reticent on information that might be of use to a competing foundry (though he hasn't been able to keep it all out, so that some information of the effect of additions of manganese, iron and nickel is given).

Some of the author's ideas are peculiar. He thinks that pickling alters the structure of the alloy and affects an appreciable depth. His ideas of fatigue are quite unorthodox and unsubstantiated. He thinks that fatigue corresponds to changes in structure such as come from cold work, so if you don't exceed the proportional limit there'll be no fatigue.

His discussion of feeding castings is general rather than specific and, in the few paragraphs devoted to wrought aluminum bronze, Durville pouring is not mentioned. In general, the booklet "Aluminum Bronze," published by the English Copper Development Assn. in 1938 is more informative. Yet the main thesis, the value of the properly-made alloy as an engineering material, is well brought out.

The book is beautifully printed on good paper with wide margins. It doesn't look like a war-time product.

—H. W. GILLETT.

Other New Books

ALUMINUM IN AIRCRAFT. *Published by Aluminum Co. of America, Pittsburgh, 1941. Paper, spiral-bound, 5½ x 8½ in., 103 pages. No charge.* Intended primarily for the newcomer to the use of aluminum in aircraft, this booklet reviews alloys and forms, airframe fabrication and treatment, choice of materials and processes, and maintenance.

LESSONS IN ARC WELDING—SECOND EDITION. *Published by The Lincoln Electric Co., Cleveland, 1941. Simulated leather, 5¾ x 8¾ in., 176 pages. Price 50c postpaid in U. S. A., 75c elsewhere.* A practical instruction book for the student welder and apprentice and a handy reference work for those more experienced.

trends

By Edwin F. Cone, Editor

Electric Steel

The greatest output of electric steel in the history of the American steel industry was recorded in 1940, emphasizing a trend which has been very prominent in the last decade. The total last year was 1,700,006 net tons of ingots and steel for castings by companies producing ingots, as computed by the American Iron and Steel Institute. The 1940 total is an increase of about 6.5 per cent over the 1,029,067 tons in 1939. The best previous total was 1,065,603 tons in 1929.

More Electric Steel

Data for the steel ingot production for the first half of 1941 show that 1,322,435 net tons of electric steel were made. The significant trend in these data is that this total exceeds both the 1929 and 1939 totals and is not very far short of the record for all of 1940 of 1,700,006 tons. At this rate the 1941 total will approximate 2,750,000 tons or perhaps exceed it.

Still More Electric Steel

The number of new installations of electric steel furnaces is mounting. Allegheny-Ludlum announces the starting up of a new 35-ton Swindell-Dressler furnace with another on the way (July). This will decidedly increase the company's capacity to make "special or high-alloy steels." The increase is estimated at 50,000 tons per year.

Steel Earnings

With an output of steel in 1940 the largest in the country's history, the average layman would expect steel company earnings to have also reached a new high. We are now told that net earnings last year, though the highest for any year since 1929, were 40 per cent lower than in that boom year in which the output was 6 per cent lower than in 1940. Trends in earnings do not always parallel those in output. With higher wages this year and a possible production of 85,000,000 to 90,000,000 tons, it is difficult to foresee the outcome.

Air Conditioning the Blast Furnace

Although the air conditioning unit at a blast furnace at the Aliquippa Works of the Jones & Laughlin Steel Corp. has been in operation too short a period to permit drawing definite conclusions, April's daily pig iron output was about 5 per cent better than in January and February, and the coke consumption was 3 per cent less than in those two months—a favorable trend. This was the testimony of E. K. Miller, asst. general supt. of the Aliquippa Works at the May meeting of the American Iron and Steel Institute.

New Blast Furnaces

As of Aug. 1 and in line with the request of the OPM for additional pig iron capacity there were six new blast furnaces being built, with a capacity of 2,019,000 tons. The OPM has asked for an increase of 6,508,950 tons capacity.

All-Welded Blast Furnace

A rebuilt blast furnace at the Steelton, Pa., plant of the Bethlehem Steel Co., adding 780,000 tons to the company's pig iron capacity, has an all-welded shell—a trend away from the riveted construction.

Pig Iron in 1940

The largest production of pig iron and ferroalloys by American furnaces since 1929 was recorded in 1940 according to statistics published by the American Iron and Steel Institute. The 1940 total was 47,398,529 net tons. The 1929 output was 47,727,661 tons.

Alloy Steel Rails

The quantity of alloy steel rails, according to the A. I. S. I., made in 1940 at 172 net tons was the smallest in many years. The record since 1925 was 5,249 tons in 1930. The use of steel rails containing alloys has been decidedly on the decline in recent years, although the trend has varied up and down. (Medium manganese rails are not included.)

The trend in the output of rails in general is upward, the largest total, at 1,678,986 net tons last year since 1930, having been made.

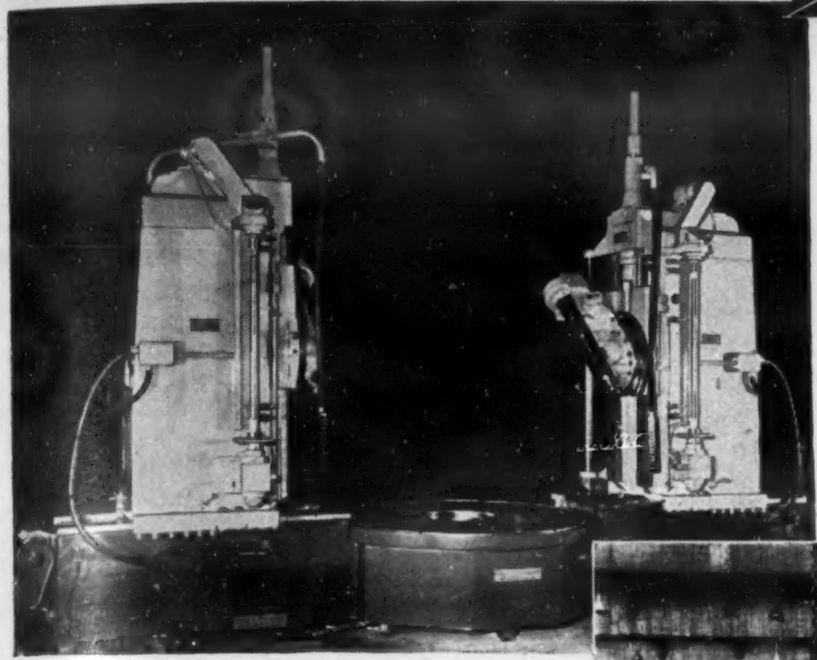
Cupolas Duplexed with the Open-Hearth

A trend of decided interest and significance has been developing for some time—duplexing the cupola with the open-hearth. Based on the experience of one steel company, it has been possible to deliver molten metal from cupolas to open-hearth furnaces. Scrap is melted in the cupolas, converting it into a product resembling pig iron. If high in sulphur, it is desulphurized with soda ash before it is transferred to the open-hearths. It is reported that by this method the production of four open-hearths has been made equal to that of six. If this is so, the building of additional open-hearths to augment steel ingot capacity has been rendered less necessary. This development is understood to have been in successful operation about 3 yrs. In fact it has been demonstrated so satisfactory and efficient that two other steel companies, similarly situated, have decided to adopt this duplexing method and to have ordered the cupolas.

(Additional "Trends" on page 398)

First Consideration in Design- ACCURACY!

First Choice in Castings- MEEHANITE!



Like a fine watch, this Gould & Eberhardt Universal Hobbing Machine, one of the largest ever built, was designed for accuracy—permanent accuracy. Fine design demands fine materials and that is why ***MEEHANITE** Castings* were used for the following parts:

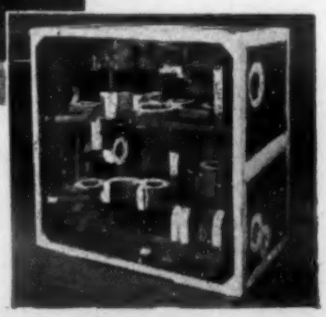
1. WORK TABLE
2. TRUNNION
3. TABLE BASE
4. STANCHION BASES
5. STANCHIONS
6. SWIVEL HEADS
7. GEAR CASE
8. WORM GEARS

Write for Bulletins
No. 9 "Machine Tool Castings"
No. 12 "Design with Confidence"

Controlled metal structure and freedom from objectionable internal stresses contribute to maintained accuracy in each casting. High tensile and transverse strengths, a true modulus of elasticity, anti-friction qualities, and high vibration damping capacity mean reliability in service and assure positive translation of superior design characteristics into the finished product.

All castings manufactured by Barnett Foundry & Machine Co., Irvington, N. J.

STANCHION



GEAR CASE

MEEHANITE RESEARCH INSTITUTE

311 ROSS STREET · PITTSBURGH, PA.

YOU KNOW WHAT YOU'RE GETTING IN MEEHANITE

Take Your Casting Problems to a Meehanite Foundry!

A-sonia, Conn.	Farrel-Birmingham Co., Inc.
Bethayres, Pa.	H. W. Butterworth & Sons Co.
Bridgewater, Mass.	The Henry Perkins Co.
Buffalo, N. Y.	Pohlman Foundry Co., Inc.
Charleston, W. Va.	Kanawha Manufacturing Co.
Chattanooga, Tenn.	Ross-Meehan Foundries
Chicago, Ill.	Greenlee Foundry Company
Cincinnati, Ohio	Cincinnati Grinders Incorporated
Cincinnati, Ohio	The Cincinnati Milling Machine Co.
Cleveland, Ohio	Fulton Foundry & Machine Co.
Denver, Colo.	The Stearns-Roger Mfg. Co.
Detroit, Mich.	Atlas Foundry Co.
Flint, Mich.	General Foundry & Mfg. Company
Hamilton, Ohio	Hamilton Foundry & Machine Co.
Irvington, N. J.	Barnett Foundry & Machine Co.
Los Angeles, Calif.	Kinney Iron Works
Milwaukee, Wis.	Koehring Company
Mt. Vernon, Ohio, Grove City, Pa.	Cooper-Bessemer Corporation
New York, N. Y.	The American Brake Shoe & Foundry Co.
Oakland, Calif.	Vulcan Foundry Company
Orillia, Canada	E. Long, Ltd.
Philadelphia, Pa.	Florence Pipe Foundry & Machine Co., (R. D. Wood Company, Selling Agents)
Phillipsburg, N. J.	Warren Foundry & Pipe Corp.
Pittsburgh, Pa.	Meehanite Metal Corporation
Pittsburgh, Pa.	Rosedale Foundry & Machine Co.
Rochester, N. Y.	American Laundry Machinery Co.
St. Louis, Mo.	Banner Iron Works
St. Paul, Minn.	Valley Iron Works
London, Eng.	The International Meehanite Metal Co., Ltd.
Waterloo, N. S. W.	Australian Meehanite Metal Co., Ltd.
Johannesburg, South Africa	Meehanite Metal Co. (S.A.) (Pty.) Ltd.

trends

By Edwin F. Cone, Editor

Plastics

A subcommittee of the committee on manufacturing problems of the American Iron and Steel Institute has made a report on displacement of steel by plastics. It points out that this displacement so far is of minor consequence, that during 1939 the total tonnage of plastics material produced amounted to only ⅓ of 1 per cent of the total tonnage of steel for the same period, and that probably less than one-quarter of that amount superseded steel. In the immediate future there are few applications which may become a direct threat to steel tonnage, as for example, automobile bodies, refrigerator liners and containers. The Institute is to review the subject periodically.

The automobile body and aircraft fuselage would be put in proper perspective if they were referred to as plywood glued together with a plastic rather than as plastics.

Tin Conservation

Certain steps for the conservation of tin, recommended to the O.P.M. by a committee of the National Academy of Science, are:

Expand use of glass containers where feasible.

Decrease the total amount of tin allotted to the can-making industry, forcing substitution.

Restrict the use of new tin for cast or wrought bronze.

Adapt bearings in new types of machinery and new models of old types to use lead-base Babbitt.

Reduce the amount of tin allowed for solid tin tubes and avoid tin-foil for wrapping purposes.

Eliminate tin for pewter and probably in galvanizing.

Alloy Steels

Despite the fact that in 1940 the production of alloy steels reached a new high at 4,965,887 net tons which was 7.41 per cent of the total steel made, also a new high, the 1941 record will probably not parallel or exceed these records. It is a foregone conclusion that the total alloy steel made this year will exceed that of last year by a substantial margin, but the percentage of the total may be less than in 1940 because of the larger relative expansion in the output of open-hearth and Bessemer steel.

Steel and Iron Foundries

There has been a very slight decrease in the number of steel foundries in the United States since 1939. An analysis of the industry by *The Foundry* shows that there are now 298 steel foundries against 299 in 1939.

In electric steel foundries there has been an expansion of 2 or 217 as compared with 215 in 1939.

There are now 3 more malleable iron foundries than there were in 1939 or 141 against 138 in 1939.

A sharp decline has taken place in the number of gray iron foundries since 1939 or from 3,054 to 3,006, a loss of 48.

More Foundries

There are 36 more foundries, ferrous and non-ferrous, in the United States now than 2 yrs. ago, or in 1939, according to a seasonal survey made by *The Foundry*. California leads with an increase of 28 with Illinois second at 16. The largest decrease was in New York, which lost 11 foundries.

Total foundries in this country in 1941 is 4,812 against 4,776 in 1939. Canada has 447 or 10 less than in 1939.

Aluminum and Non-Ferrous Foundries

There are now 45 more foundries making aluminum and aluminum alloy castings than there were in 1939 or 2,174 in 1941 against 2,129—a natural development under present conditions.

The expansion in the total number of non-ferrous foundries in the last 2 yrs. has been 51 or 2,798 in 1941 vs 2,747 in 1939.

To Conserve Manganese

Among certain suggestions for conserving manganese in the steel industry, made by Dr. R. R. Sayres, director of the U.S. Bureau of Mines, the following may be mentioned:

1. Make certain that the steel does not contain more manganese than necessary for the purpose for which it is to be used.
2. Substitution of alloys containing less manganese for those containing more—spiegeleisen for ferromanganese.
3. Substitution of other deoxidizing agents such as zirconium and titanium.
4. Use of furnace procedures designed to yield a high residual manganese metal at the end of the heat.

Rail Testing

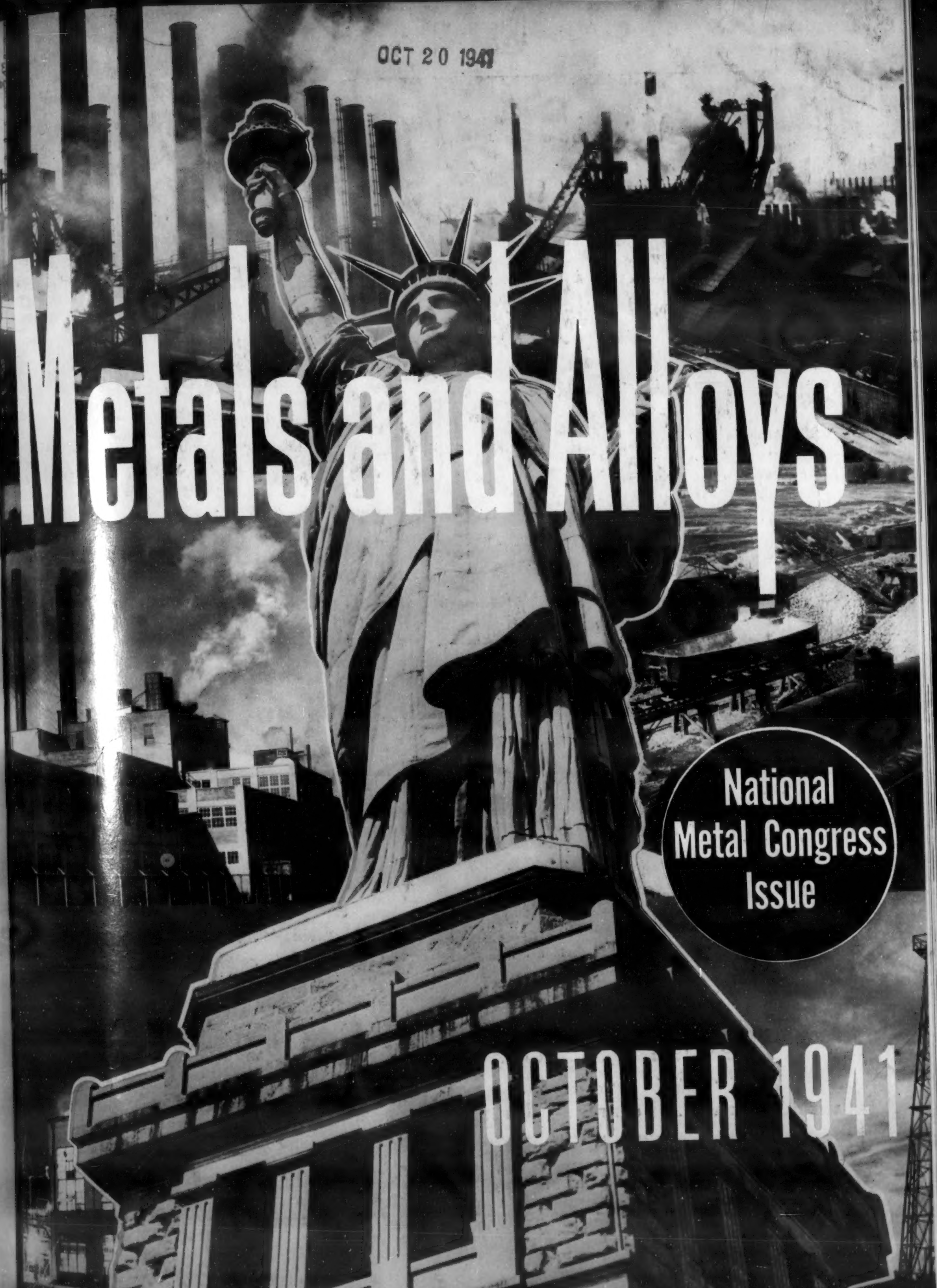
The testing of rails by the Sperry method continues to expand. In 1940 over 102,880 track miles were tested as against about 82,000 in 1939. Eleven years ago or in 1930 the track miles so tested were only 30,000.

In 1940, Sperry detector cars located over 52,000 defective rails or approximately 4,000 more than in any previous year.

Alaskan Strategic Metals

The U. S. Geological Survey has perfected plans for the intensive exploration of minerals in Alaska which may contain workable proportions of the strategic metals—tin, nickel, chromium and mercury. Some of this is a continuance of earlier searches—both tin and chromium ores have been found but not fully explored.

(Additional "Trends" on page 396)


Metals and Alloys
National Metal Congress Issue
OCTOBER 1941